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ESTIMATING SURVIVORS AND RESOURCES REMAINING AFTER A NUCLEAR DETONATION FOR CIVIL DEFENSE PURPOSES

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Preface

In the event of war, continuing appraisals of the extent of resources available and their locations will be needed at all levels of government to furnish officials information for undertaking actions to ensure the highest probability our nation will survive and recover. This manual furnishes information how such appraisals may be made.

A necessary first step for estimating the locations and quantities of resources remaining after an attack would be an assessment of the damage to both human and material resources. To be able to perform such an assessment, a local official needs to identify and know in advance what resources will be required in the immediate postattack period and where they are located. After an explosion, a local official will have to determine where the nuclear weapons detonated, the yields of the weapons, the types of bursts and the extent of area involved in order know how the resources were affected. This manual identifies the types of resources and information which local officials can use as a guide for collecting locational and quantitative data.

Information about the resources required for survival and recovery --- locations and quantities -- must be obtained from those organizations in government responsible for their jurisdiction. To be valid and useful, the information should be kept up-to-date. This manual furnishes guidance how such information may be presented in graphic form and used in an emergency for estimation purposes.

Following attack, accurate and detailed information regarding nuclear detonations may not be available for a considerable period. Therefore, until such information becomes available, it may be necessary for organizations to develop from scanty and fragmentary reports attack information for estimation purposes. This manual explains how civil defense organizations may perform an attack analysis.

Knowledge of the probable effects of the various types of nuclear bursts an enemy may employ is needed so that the impact of those effects on resources may be calculated. This manual contains weapons effects data which will aid civil defense officials to make such calculations.

Equipped with a knowledge of the resources in his area, able to estimate the locations and types of weapons which had exploded and knowing what the effects of such weapons might be, local officials can come to reasonable conclusions about the resources that may have been lost as well as the resources that may have survived. Local officials will require these types of information for undertaking proper and appropriate actions for immediate survival and ultimate recovery.

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Introduction

This manual presents graphic techniques and procedures to be performed manually for use primarily by State and local civil defense organizations for estimating damage resulting from a nuclear detonation. Damage estimation is the process of predicting the effects of enemy attack upon the human and material resources located within an area. Its purpose is to furnish operating officials estimates of the amounts and locations of populations and resources that may be expected to remain postattack so that intelligent decisions for survival and recovery can be made.

In the first few hours or days after attack, officials at all levels of local governments will find it difficult to obtain a total picture of the effects resulting from a nuclear attack within their particular jurisdictions. The radiological situations and disruptions of normal conditions and channels of communications will make it difficult for officials to collect or receive information. Experience with large scale natural disaster indicates officials are unable to furnish, particularly in the period immediately following a disaster, accurate information as to the extent of damage and number of casualties.

Attack area officials will assemble fragmentary information and develop as accurate a picture as possible. Fragmentary reports, however, do not enable operating officials to estimate the probable total situation so that intelligent and realistic decisions can be made. The methodology, described herein, involves the preparation and use of maps and nuclear weapons effects templates. The maps depict the preattack locations of resources; the templates depict the extent of the probable zones of blast, thermal and casualty damage. Application of the techniques and procedures, described herein, will furnish officials the appropriate information required for estimating the probable total situation as well as for undertaking evaluations of contemplated courses of action.

There are many uncertainties involved in the damage estimation process. For example, the complex nature of nuclear effects, the inherent difficulties encountered, during tests, in making exact measurements of weapons effects, the marked difference two weapons, having the same explosive energy yield but different design, may have in their actual effects and lastly, but no less significant, the difficulties of depicting the exact location of resources on small scale maps. Consequently the application of simplified and/or sophisticated techniques inevitably produces approximations. Only ground reconnaissance and detailed surveys or censuses of people and important resources may furnish exact evaluations and accurate information on the number of people and resources remaining.

The procedures herein have been designed to produce rapidly statistical estimates of the magnitude of the problems civil defense organizations may encounter after an attack. Estimates for individual facilities therefore should be considered as probable effects and not as an exact evaluation. As reconnaissance information becomes available, the actual data collected should supplant the estimates developed by manual procedures.

The individual procedures for the various features and resources, developed and described herein, are based on weapons effects information contained in "The Effects of Nuclear Weapons", April 1962, prepared by the Department of Defense and published by the U.S. Atomic Energy Commission. Weapons effects data for yields 1 - 3 - 5 - 10 - 20 megatons only are included herein. Radii of damage, in terms of miles, are furnished to enable personnel to estimate damage without having to cope with technical material and mathematical formulae to obtain such data when required.

The ease with which quick-reference information may be obtained necessitates simplicity of presentation, required by those new to the weapons field and desired for many purposes by fully informed personnel from technical to professional levels. Therefore, as a convenience to those using this document, the arrangement of the information has been designed as follows:

a. general information useful to all personnel has been incorporated within the first five chapters.

b. Specific information required by individuals to develop estimates of damage for a particular resource has been incorporated in the appropriate chapters dealing with resources, such as: population, housing, communications, water, transportation and so on.

c. Reference information, furnishing additional and/or detailed descriptions and explanatory material, has been incorporated in the appendices.

The methods and procedures presented herein are recommended for use. Alternate improved methods may be worked out in some instances. Maximum utilization should be made of available maps and data in governmental and other public offices and agencies as well as those in private institutions.

Assembling and presenting resource location information and data graphically on maps is only the first step in the damage estimating process. Assuming a hypothetical attack and estimating the probable damage will furnish training and experience to civil defense personnel in the use of the techniques and procedures described herein. In this manner, the techniques and procedures can be of practical use rather than as mere reference material to be looked at occassionally before the attack or to be referred to after the attack.

Chapter 1

The Damage Estimation System

Estimation Versus Assessment

Estimating damage from a nuclear detonation for civil defense purposes requires reorientation in our thinking. Following a natural disaster, local authorities generally ascertain the number of casualties and physical damage sustained. The procedure involves ground reconnaissance for assessing the damage or a damage assessment process. Following a nuclear detonation, however, the blast, thermal and radiation conditions may prevent local authorities from immediately performing reconnaissance to determine the existing situation. Also, normal channels of communications upon which communities habitually depend for obtaining information may not be available. Consequently, local (and State) authorities may have to depend on the use of an estimation rather than an assessment procedure. The estimation system, described herein, involves the use of map analysis techniques in conjunction with nuclear weapons effects templates to obtain an estimate of the probable total situation. By estimating the probable casualties and damage to resources and subtracting the losses from the preattack population and inventory of resources, authorities will be able to estimate the probable number of people and amounts of resources remaining. The process involves estimating the probable damage sustained as distinguished from actually ascertaining or assessing the damage.

Estimation Versus Reporting Inventories of Resources Remaining Postattack

As soon as the radiological situation permits, following an enemy attack, State and local authorities will perform ground reconnaissance and conduct detailed surveys and censuses to determine the number of people and amounts and locations of resources remaining. Procedures for reporting what the exact situation is at each level of government, based on reconnaissance, surveys and censuses, does not require a knowledge of weapons effects, locations of ground zeros, weapons size, type of burst, time of detonation, locations of resources, and the meteorological conditions and evasive actions taken at the time of attack. The process involves recordingthe desired information onto forms, prepared in advance, and transmitting the information to the next higher echelon. Thus, for reporting the actual inventories of resources remaining postattack application of the damage estimation system is not required.

Elements of the Damage Estimation System

Application of damage estimation techniques require a system composed of:

a. Locating the preattack population and resources on maps

b. Availability of damage templates based on predictions of effects of nuclear weapons

c. Nuclear attack or detonation data - weapon size (yield), type of burst, location of ground zero, and time of detonation

d. Meteorological conditions and evasive actions taken at time of detonation.

The general methodology is simply to superimpose the appropriate damage templates on the resource maps desired and estimate the effects of the attack. The damage templates eliminate the process of measuring, or calculating mathematically, the relationship between the locations of population and resources and those of the nuclear detonation points.

Principal Uses for Estimates of Damage

Data obtained from the damage estimation process are used principally for the following purposes:

a. To assist State and local authorities to develop an estimate of the total situation

b. To assist the civil defense service in making decisions in consonance with the magnitude of the problems they may encounter

c. To assist the civil defense services in developing their requirements for conducting postattack operations and survival of the population

d. To identify, as quickly as possible following an attack, critical shortages in resources required for survival of the population

e. To develop a sound tactical organization of the ground for the most effective use and control of the personnel, equipment, supplies, and facilities available postattack

Features and Resources to be Located on Maps

For damage estimation purposes, locational and quantitative information for the following features and resources is collected. A map should be prepared for each feature and resource. The locational information is presented graphically on maps. At each location on the map, an annotation is indicated for identification purposes and rapid reference to tabular material containing quantitative statements of capacity, size or other implications of importance.

1. Population distribution
2. Elementary and Secondary Schools and Institutions of High Education
3. Housing (Dwelling Units)
4. Government Facilities (Headquarters and Field)
5. Law Enforcement Facilities and Personnel
6. Fire Stations and Personnel
7. Rescue Units and Location of Stored Tools
8. Hospitals and Local Health Departments and Clinics
9. Medical Manpower - doctors, osteopaths, dentists, veterinarians, professional nurses, pharmacists, sanitary engineers
10. Food stocks at wholesale, retail and consumer levels
11. Public Fallout Shelter Spaces Available
12. Water Supply and Distribution Systems and Auxiliary Sources
13. Electric Power System and Utility Stocks for Restoration of Service
14. Fuel Storage (capacity below 25,000 bbls)
15. Solid Fuel Storage
16. Communications - Domestic telegraph and telephone offices-conelrad radio stations - AM broadcast stations - FM radio stations - TV broadcast stations
17. Welfare Offices and Personnel
18. Transportation - bridges - tunnels - airports and airfields - streetcars, trolleys, buslines, and vehicle storage yards - streets and highways - motor trucks
19. Potential hospitals - public building, hotels, nursing homes

These features and resources are listed in Appendix A with a list of suggested information sources.

Only the locational information collected for the features and resources listed above will appear on the maps. Some of the information and data collected are best presented in tabular form for use in connection with the maps during the damage estimation process. Information of this type includes names and addresses of facilities, inventories of equipment and supplies and statistics regarding personnel. In general, only locational features should be mapped whose significance results from their location relative to possible ground zero (point on ground directly under a nuclear detonation).

Chapter 2

Maps Used For Estimation Purposes

Maps are the most valuable of tools to be used in the damage estimation process. A wide variety of information can be presented on maps in a simple, easily understandable and usable form. Maps with locational information plotted thereon and properly annotated reveal clustering of resources, spatial relationships and emphasize features which are significant primarily because of their relative locations. For example, broad parkways separating densely built up areas constitute important firebreaks. Parkways traversing areas with widely scattered buildings have little fire protection significance.

Map Sources

The principal sources of maps used in the damage estimation process are:

a. Census maps of tracts and enumeration districts, prepared by the Bureau of Census, Washington, D. C.

b. Special purpose and municipal maps, prepared by local municipal offices or by private map companies.

c. Topographic maps, published by the U.S. Geological Survey and the Army Map Service.

d. Lattice locational and other types of maps, prepared by Office of Civil Defense. A detailed discussion of maps, sources and supplementary information is present in Appendix B.

Selection of a Base Map

All features and resources for which an estimate of probable damage is desired should be presented on copies of the same scale map. Use of a map having the same scale simplifies the use of damage templates, comparison of different resources, and transfer of information from one map to another.

In general, standardization of map scale to secure uniformity for all geographic areas - State, County, Standard Metropolitan Statistical Area, urbanized area, city - is not feasible. A scale suitable for a State would be too small for an urbanized area and, conversely, a scale suitable for a city would be too large for use by a State. Furthermore, adoption of a standard scale for all areas within a State would seriously limit the usefulness of numerous existing maps and would result in a waste of time, effort, and funds.

Where existing scale maps are already being used by a civil defense organization factors to consider in selection for damage estimation purposes are relative accuracy, amount of pertinent information depicted, suitability of scales, and overall sizes.

Recommended map scales for use for damage estimation purposes are:

Area	Type of Resource	Direct Effects (Blast Area)	Fallout Effects
State	All resources located outside urbanized areas	1:1,000,000	1:2,500,000
	Resources located in urbanized area	1:250,000 or 1:500,000	1:2,500,000
County	All resources located outside urbanized area	1:500,000	1:2,500,000
	Resources located in urbanized area	1:250,000	1:2,500,000

Area	Type of Resource	Direct Effects (Blast Area)	Fallout Effects
Standard Metropolitan Statistical Area	All resources	1:500,000 or 1:250,000	1:2,500,000
Urbanized area or city	All resources	1:250,000 or 1:24,000 (approximately)	1:2,500,000

Desirable Characteristics of Maps

Maps prepared for damage estimation uses should be clear, easy to read, and free of unnecessary detail. Locations of only one feature or resource should be depicted on a single map. Conflicting features, such as traffic arteries, power lines, gas mains, and similar linear features that lie parallel to each other and close together should be represented on separate maps.

Map scales should be examined with care. They should be of the graphic type consisting of a line or bar marked off into miles and fractions thereof. Such scales maintain the proper relationship to the distances represented when the map is copied on a larger or smaller scale. However, even graphic scales are subject to error. They may have been incorrectly drawn originally, or may have been photographically enlarged or reduced separately from the map on which they appear. Therefore, the map scale should be checked by comparing the mileage between the two points on a map of known accuracy. Errors in map scale may be serious and may introduce fundamental errors.

Mapping costs should be kept at a minimum. Wherever practicable, existing maps should be used. Sometimes they may be used with no change, at other times they require small alterations, such as pasting on a new legend. Finished drafting should be avoided except on the few maps which will be reproduced for distribution. Preliminary drafting and alterations should be made in colored pencil. These pencils may be used also on final copies of maps which are not intended for distribution.

Maps intended for distribution should be prepared in black and white to avoid the expense of color reproduction.

For damage estimation purposes, separate paper maps are preferable to transparent (acetate) overlays which would be superimposed on a single map. Paper maps are much less expensive, more easily handled and less susceptible to damage. They are easier to draw and alter, and are much easier to read than overlays. Paper maps also are free from surface reflections which commonly obscure map features when overlays are used.

Chapter 3

Locating Features and Resources on Maps

Essential to the graphic method of estimating damage resulting from the detonation of a nuclear weapon is the availability of maps depicting the locations of features and resources. When a nuclear weapon detonates, the effects inflict different types of damage on people, features and structures depending on their relative distance from the ground zero location. By depicting the locations of the population, features or structures containing resources on maps and superimposing on the maps the appropriate nculear weapon effects templates in such a way that the centers of the templates correspond to the loca tion of ground zero, an estimate of the damage may be developed.

Position Reference Systems

Various position reference systems have been developed for use on maps to facilitate the location of a point. The three most commonly used systems are: (a) a rectangular coordinate system (b) a geographic coordinate system and (c) the Universal Transverse Mercator coordinate system.

Rectangular Coordinate System

The rectangular coordinate system, employed by private cartographic organizations, is generally superimposed on raod, city and state maps prepared for commercial purposes. The rectangular coordinate system consists of a series of vertical and horizontal coordinates. These lines intersect and form a matrix of rectangles. To identify each rectangle, a combination of alphabetic letters and numbers is employed. Each rectangle, thus, can be identified by a code consisting of an alphabetic letter and a number. On city maps, the "Index to Streets" lists the names of the streets in alphabetic order. Shown for each street is the identifying rectangle in which it is located. Example:

Schematic Illustration

	1	2	3	4
A	A1	A2	A3	A4
B	B1	B2	B3	B4

This system enables individuals to locate desired streets on maps rapidly. In general, maps produced by commercial organizations do not show the geographic and/or UTM coordinates.

Geographic Coordinate System

The geographic coordinate system is generally employed by governmental organizations producing maps. The geographic coordinates, when superimposed upon a map for an area, divide the area into quadrangles formed by meridians of longitude and parallels of latitude. A distance a point is west of the prime meridian (Greenwich, England) is called its longitude. A point position on a map employing the geographic coordinate system, therefore, is identified by its latitude and longitude coordinate readings. Thus, a point position can be identified by four numbers for degrees and minutes of latitude and five numbers for degrees and minutes of longitude. All USGS and AMS maps depict the geographic coordinates. Figure 3.1 presents a map of the United States utilizing the geographic coordinate system.

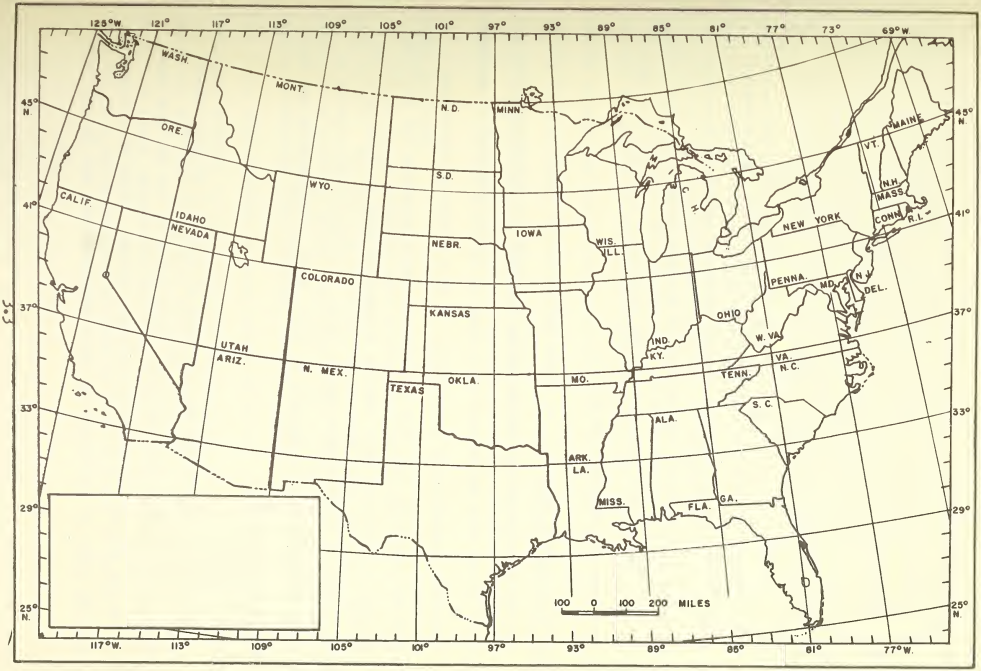


Figure 3.1

OCD BC 15302

UTM Coordinate System

The Universal Transverse Mercator coordinate or UTM system was developed by the Army Map Service for military use. The system enables the identification of locations in terms of meters. A detailed description of the system is contained in Appendix B, page B-58, "Explanation and Use of the UTM Grid".

The UTM position reference system was adopted for estimating damage nationally by electronic computers because locations expressed in meters simplifies the mathematical computations of distance between two locations, such as the location of a resource and the location of a ground zero where both locations are expressed in meters.

GEOREF Coordinate System

The World Geographic Reference System (GEOREF) is a worldwide position reference system that may be applied to maps or charts graduated in latitude and longitude, regardless of projection. It is a method of expressing latitude and longitude in a form suitable for rapid reporting and plotting and is used for plotting early warning information such as tracking of incoming flights of enemy bombers and so forth. A detailed description of the system is contained in Appendix B, page B-73 "Explanation and Use of the GEOREF System".

Location Systems

For purposes of plotting the locations of resources on maps, three locational systems have been utilized. Each system is for use with maps depicting the appropriate position reference system. Lists of resources showing the names of facilities and their addresses only are for use with maps depicting the street pattern, the names of streets, a rectangular coordinate system and an "Index of Streets" which facilitate locating a position on the maps. Lists of resources showing the names of facilities and their location in terms of lat-long only are for use with maps depicting the geographic coordinate system. Lists of resources showing the names of facilities and their location in terms of UTM information are for use with maps depicting the UTM coordinate system.

Present lists of Resources pertaining to facilities, available at National Headquarters, furnish for each facility the name and street address as well as the UTM locational information. Although lat-long locational system is used for the National Location Code, it is generally not employed at the National level for estimating damage by electronic computer procedures. Lat-long information for locations of Resources pertaining to facilities, therefore, is not available.

Point Locations

Ordinarily, a facility, when plotted on a map by means of a dot appears as a "point". The plotting of facilities on maps, therefore, has been referred to as plotting "point locations". Facilities, such as: Manufacturing plants, warehouses, radio stations, bridges, electric generating stations and so on, when depicted on maps, appear as points. The "point location" technique, however, is not limited to facilities only. The locations of Resources, such as: population, housing, food and so on, distributed over an area (a tract, enumeration district, minor civil division, census county division) also can be depicted on a map by means of a dot or "point". By assuming the total for a specific Resource is located at the approximate center of a geographic area, the location of the Resource can be plotted as a "point" on a map. The Standard Location Area (SLA) system, developed by OCD, employs this technique. The SLA system divides the U.S. and its outlying areas of sovereignty or jurisdiction into small geographic areas. All the SLA's are explicitly defined areas with rigid geographic boundaries. Each SLA is represented by a pair of geographic coordinates - lat-long and a UTM coordinates. By associating the Resource within each SLA with the appropriate geographic coordinates, the distribution of the Resource is defined. Use of the SLA system enables the plotting and use of the extensive tabulations of census small area data promulgated by the Bureau of Census, Department of Commerce, for damage estimation purposes, if desired.

Locations of Resources, distributed over a geographic area, can be plotted as "points" on maps by means other than the Standard Location Area system. For example, the totals of a Resource within a geographic area, such as: a 20 - 10 - 5 - 2.5 kilometer square can be aggregated and the approximate center of the square used as the location point for the Resource. Use of electronic computers facilitates aggregating Resources located within a specified kilometer square. Computer printouts have been prepared and disseminated showing for the various Resources the total quantities located within a 10+5 kilometer square. The printouts furnished the UTM grid coordinates, names of facilities and the total quantities located within the kilometer squares. The printouts were not maps; they furnished columns of quantitative data. Electronic computers, however, are capable of producing printed sheets, 8" x 10½", depicting crossed vertical and horizontal lines forming a matrix of kilometer squares. The size of the squares may be 10 - 5 - 2.5 kilometer squares depending on the scale selected. The crossed lines form a "lattice" - an openwork of squares. Consequently, the sheets are called "Lattice Preplots of Resources". At the left side of the sheet, appear the Northing UTM coordinates; at the bottom, appear the Easting UTM coordinates. The figures within each kilometer square represent the total quantities of the Resource located within the kilometer square. The size of the individual squares for the lattice network selected by OCD for estimating damage manually at the local level is 2.5 X 2.5 kilometers. The scale is 1:250,000. Figure 3.2 furnishes a schematic illustration of a lattice preplot for population.

Detailed instructions for use of these preplot sheets in conjunction with damage templates for estimation purposes will be found in the appropriate chapters pertaining to the various Resources included in this document.

Linear Features

The plotting of linear features, such as: traffic arteries, power lines, transportation lines, gas mains, water distribution system, communication lines, ordinarily are depicted on maps in the form of lines. However, even linear features may be graphically depicted on maps by means of "points". Breaking a line into segments of $\frac{1}{2}$-1-$1\frac{1}{2}$ miles and plotting a point for each segment permits conversion of linear features into a series of points. Presentation of linear features on maps in this manner facilitates estimating the number of miles of damage sustained.

Lattice Location of Population
Resident Population 1963 (Projected Data)
Standard Metropolitan Statistical Area Total 1847 (100's)

UTM Zone XX
Scale 1:250,000

(2.5 X 2.5 Kilometer Squares)

Northing	2355–2380	2380–2405	2405–2430	2430–2455	2455–2480	2480–2505	2505–2530	2530–2555	2555–2580	2580–2605	2605–2630	2630–2655	2655–2680	2680–2705	2705–2730	2730–2755
45950–45925																
45925–45900			4			2				1				3	1	
45900–45875				1										26	1	
45875–45850					1			1		1						
45850–45825			1	3	8	4	5	6	9	7		1		1		
45825–45800			1	12	24	52	36	34	40	21	3					
45800–45775			2	14	43	72	65	67	62	12	5	1				
45775–45750			8	30	52	102	83	52	42	17	7	2	1			
45750–45725			2	14	21	41	60	36	48	16	3					
45725–45700		1	2	16	42	64	70	32	36	14	4	1				
45700–45675				12	30	55	45	30	22	18	6					
45675–45650			1	6	10	8	9	7	4	6	2					
45650–45625				1	2	3	4	5	2	4	1					
45625–45600	1		1			1		1		1		1				
45600–45575		1		1			1		1							
45575–45550	1		1		1											

Easting
Figure 3.2

Plotting Information on Maps

The graphic presentation of information on maps should be simple and clear. Use of pictograms, sketches and ornamental symbols is not essential. For most resources, a dot that is clear and easy to read is sufficient. However, for those individuals who may desire to employ sophisticated techniques for presenting information graphically on maps, appendix B, pages B-20 thru B-40 furnish detailed instructional material.

Chapter 4

Attack Analysis

Attack Data

In estimating damage manually by use of maps and nuclear effects templates, it is necessary to know for a nuclear detonation the following attack data:

a. time of explosion

b. geographic location of ground zero

c. yield or weapon size

d. type of burst

e. meteorological conditions at time of detonation

Time of detonation and the meteorological conditions are required for casualty estimation, forecasting areas of fallout deposition and estimating dose rates and dose at specified time periods.

The geographic location of ground zero is required for the purpose of placing the desired nuclear effects templates at the appropriate position on the maps depicting resource locations.

The weapon size and type of burst for the detonation are needed to prepare the appropriate scaled nuclear effects templates. The radii for estimating blast damage and casualties vary with each weapon size and type of burst. The appropriate damage and casualty radii therefore have to be used for estimation purposes.

Attack Analysis

For purposes of preattack planning, exercises and training in estimating damage, it is the general custom to furnish the attack data for each nuclear detonation. The attack data are known and therefore the process of estimating the yield, location of ground zero and type of burst for a nuclear detonation are not involved.

Following enemy attack, however, the location of ground zero, weapon size and type of burst for a nuclear detonation may not be readily available to State and local civil defense organizations either because of the radiological situation that may exist or inability to conduct ground reconnaissance to collect information which may be used as a basis for developing the desired data for damage estimation purposes. Civil defense organizations, consequently, may have to employ estimating procedures to derive the desired information.

The development of an automatic surveillance system which will furnish the nuclear detonation information for damage estimation purposes is presently under consideration; however, blanket coverage for all targets is not envisaged. Civil defense organizations, therefore, will have to rely on estimating procedures involving analysis of fragmentary information relating to phenomena associated with a nuclear detonation for deriving the location of ground zero, weapon size and type of burst.

The process of analyzing reports of phenomena associated with nuclear detonations and converting such information into usable form for damage estimation purposes is referred to as "attack analysis". Attack analysis involves evaluating the various pieces of information reported by a multitude of individuals as to reliability of source, content and usability for deriving the location of ground zero, weapon size and type of burst.

Estimating Yield of a Nuclear Detonation

Associated with a nuclear detonation are several characteristic phenomena which are visible and/or audible that can be utilized to provide desired and useful information. For example, following a nuclear detonation there is the appearance of a ball of fire, the sound of the explosion and the formation of a cloud having the characteristics and appearance of a mushroom. All of these phenomena, if observed by individuals trained to report the appropriate information to the civil defense organization, can be useful for developing the yield and location of ground zero.

Ball of Fire or Flash Estimation Procedure

Immediately after a nuclear weapon detonates there is the appearance of a ball of fire. The duration of the brilliance of the fireball or flash can furnish an estimate of weapon yield. Appendix C contains a table which furnishes for various weapon yields the estimated number of seconds the flash phenomena may last. An estimate of the weapon yield, therefore, can be derived from reports indicating the length of time the flash phenomena was observed.

Nuclear Cloud Estimation Procedure

The paremeters of the nuclear cloud, such as: height of the top, height of the bottom and the diameter size also can be used for estimating weapon size. The mushroom cloud attains its maximum altitude and tends to become stabilized in height within about 7 to 10 minutes after the explosion. The height to which the nuclear cloud ascends and the diameter to which it grows depends upon the yield of the nuclear explosion and upon atmospheric conditions. The nuclear cloud remains visible for about an hour before it is dispersed by the winds into the surrounding atomosphere with other clouds in the sky. In Appendix C, various techniques for estimating weapon yield, based upon the paremeters of a nuclear cloud, are included.

Nuclear explosion phenomena must be observed and recorded in order to provide the data necessary for estimating nuclear burst paremeters. Since nuclear explosions may occur simultaneously or in close succession, a format similar to the following should be designed for recording appropriate information for each explosion:

FLASH PHENOMENA						CLOUD PHENOMENA						
Explosion Number	Date and Local Time Observed	Type (Air Ground or Water)	Direction Observed	General Location	Flash-to-Bang Time (Seconds)	Date and Local Time Observed	Height of Top of Cloud (ft)	Height of Bottom of Cloud (ft)	Cloud Top Angle (degs or mils)	Cloud Bottom Angle (degs or mils)	Cloud Dia. Angle (deg or mils)	Azimuth to Cloud Stem

It is possible that any one observer may not observe and/or record all the above information. It is imperative, therefore, that all observers obtain and record enough information to provide civil defense personnel sufficient data for estimation purposes.

The importance of individual observer understanding and know-how to use the material contained in Appendix C cannot be overemphasized. Observer understanding and familiarity with the techniques and procedures, contained in Appendix C, will facilitate to a great extent in determining yield and location of ground zero.

Estimating Location of Ground Zero

Ground zero is the point on the surface at which the nuclear explosion occurs. Should a nuclear explosion occur either in the air or beneath the surface, ground zero is the point on the surface directly below or above the explosion. The location of ground zero can be determined by direct observation, intersecting azimuths to the nuclear cloud, or by using the flash-to-bang time to compute the distance along a single azimuth. In Appendix C are included estimating procedures and instructions.

Converting Qualitative Descriptions of Weapon Yield to a Specified Yield

For estimating damage, yields of nuclear detonations expressed in quantitative terms, such as: 1 MT, 5 MT, 10 MT etc. are required. Yields described as small, medium and large, consequently, should be converted to a specific size. The following criteria may be used for conversion purposes:

small	-	all size below 1 MT
medium	-	1 MT thru 5 MT
large	-	6 MT and above

Chapter 5

Nuclear Weapons Effects

Factors Required for Estimation Purposes

A great deal of information has been published regarding nuclear weapons - characteristics, phenomena and damaging effects. Most of the material consists of detailed descriptions and technical explanations of the complex phenomena of blast, thermal and the various radiations associated with nuclear explosions. The published information is complex, highly technical and difficult to apply for damage estimation purposes. Descriptions and technical explanations are academically interesting; however, they do not furnish readily usable data for estimating damage. Required for the process of estimation are nuclear effects information in the form of quantitative data--casualty multipliers, radii of damage for the weapon effects, yields and types of bursts--and brief descriptive phrases of the types of damage inflicted to structures, objects and people within the various damage ranges. A knowledge of the levels of peak overpressure (psi), which cause a specified type of blast damage, is not essential for estimation purposes when the damage radii are available. The psi criteria which cause a specified type of blast damage, consequently, are not included herein.

The estimating techniques, procedures and nuclear effects damage radii data, contained in this document, can be applied for obtaining estimates of damage without thoroughly understanding the complexities of the phenomena associated with nuclear explosions. A general understanding of nuclear weapons - their characteristics and effects - however, will contribute materially to a better utilization of the material herein. For this reason, therefore, basic nuclear information has been developed. Appendix D presents brief but pertinent information regarding nuclear weapons characteristics, phenomena and effects which should prove useful as background information and assist in properly utilizing the techniques, procedures and data.

Estimating "Direct" and "Indirect" Effects

The blast, thermal and radiation phenomena resulting from the detonation of a nuclear weapon produce casualties and damage structures, facilities and material objects. When a nuclear weapon of known yield is detonated on the surface, at a particular height in the air, or at a particular depth below the surface, the ranges of the immediate effects are fairly well defined. There will be an area surrounding ground zero within which the destruction due to blast and shock, and accompanying fires will be great. Beyond the inner area of severe damage, there will be an area in which moderate damage is inflicted. At considerably greater distances, the immediate effects will be weaker and damage to structures will be minor, e.g. broken windows and damage to window frames and doors. The distances from ground zero within which various degrees of destruction may be expected depend primarily upon the energy yield of the explosion and the conditions of burst, i.e., air, surface, etc. The topography and weather influence these distances. The extent of damage within the blast area is reasonably predictable. Effects from fallout, which result from surface detonations, and damage from fire, on the hand, are less predictable.

Casualties and damage within the blast area, generally referred to as "direct effects", can be reasonably estimated. Effects extending beyond the blast area, generally referred to as "indirect effects", are less predictable. The extent of damage from fire and the effects from fallout can range between wide extremes depending on a combination of many circumstances. For example, the extent of fire damage will depend on building density, fuel factors such as combustibility of structures, firebreaks, continuity of combustible construction, fuel value of building contents, size of buildings and the pattern of air temperature, relative humidity, wind velocity and recentness and amount of precipitation. Similarly, the extent and nature of the fallout will be determined by a combination of circumstances associated with the energy yield and design of the weapon, the height of explosion, the nature of the surface beneath the point of burst and the meteorological conditions. These varied factors are complex, difficult to interrelate and to analyze. Estimating fire damage and fallout effects, consequently, inevitably produce rough approximations and such estimates should be used cautiously.

Use of Idealized Patterns for Estimation Purposes

During World War II, conventional weapons were capable of destroying an entire city block and were referred to as "block busters". Nuclear weapons, however, effect relatively large geographic areas and have been referred to as "city busters". For example, a 1 MT inflicts damage to approximately 170 square miles; a 20 MT inflicts damage to 550 square miles. In addition, fallout from a nuclear surface detonation may cover as much as 7,000 square miles. To enable personnel to comprehend and estimate the magnitude of the damage a nuclear weapon can inflict on an extensive geographic area, idealized casualty, fire, blast damage and fallout patterns have been developed. The patterns do not indicate irregularities which undoubtedly occur in a real attack situation, because the conditions determining such irregularities are highly variable and uncertain. The patterns have been deliberately smoothed out for estimation purposes. Actually, the patterns would be distorted by the conditions of terrain, weather, etc. Two or more weapons detonated within a short distance of each other, of course, change the shape of the patterns. Nevertheless, in spite of their limitations, the idealized patterns are useful for developing estimates of the overall situation. In some instances, the patterns will undoubtedly underestimate; in others, overestimate. However, the total estimates for the whole area affected should not be greatly in error.

Blast damage radii data for various weapon sizes and types of bursts have been developed for various types of structures, features and objects and are included in the appropriate chapters of this document. These will enable personnel to develop idealized patterns as required. The values of the radii have been rounded off to the nearest tenth of a mile; greater precision is not warranted. The radii should be considered to be within plus or minus 20 percent of what they may be in an actual attack.

The damage radii data are for certain average target conditions. These presuppose:

1. The target is at sea level.
2. The terrain is fairly flat (rugged terrain may provide some local shielding and protection in certain areas; in others, it may enhance the damage).
3. The structures have average characteristics (they are of average size and strength and their orientation with respect to the burst is no problem - the ratio of loading to resistance is relatively the same in all directions from the target).

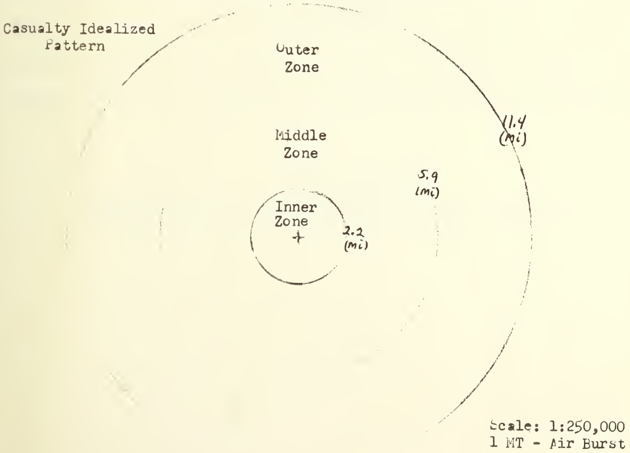
In applying the estimation procedures to conditions which depart appreciably from the average, modifications may be necessary. This is left to the judgment of the analyst.

Shapes of Idealized Patterns

In general, two distinct shaped idealized patterns are employed for estimation purposes. A circular shaped pattern is used for estimating casualties and blast, fire and glass damage. A "cigar" shaped pattern is used for depicting areas of fallout deposition.

Casualties

For estimating casualties, three zones, representing different distances from ground zero are depicted on the idealized pattern - an inner, middle and outer zone. The following schematic illustration presents the shape and depicts the three zones of the casualty pattern for an air burst:



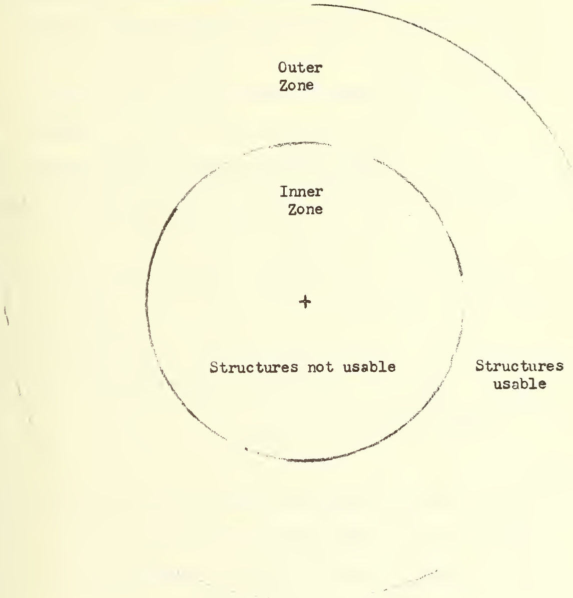
Casualty radii for various weapon sizes and types of burst, samples of idealized patterns for estimating casualties from air and surface detonations and multiple detonations, casualty multipliers for air and surface bursts and detailed instructions for deriving casualties from direct and indirect effects are included in Chapter 7.

Blast Damage

For estimating blast damage to structures, facilities and objects, two zones, representing different distances from ground zero are depicted on the idealized pattern - an inner and outer zone. The inner zone represents the area in which structures, facilities and objects are not usable for survival operations purposes. They sustained severe or moderate damage, that is, either complete destruction or major repairs are required, thus, precluding their effective use. The outer zone represents the area in which light damage is inflicted and, consequently, the effective use for survival operations of the structures, facilities and objects are not precluded. The following schematic illustration presents the shape and depicts the two zones of the blast damage pattern:

Idealized Blast Damage Pattern

5.5
6.6
12.5



Scale - 1:250,000
1 MT -Air Burst
(Height of burst chosen to maximize radius of damage for type of structure under consideration)

The definitions of the terms severe, moderate and light, as they apply to various types of structures, facilities and objects, will be found in subsequent paragraphs.

For damage estimation purposes, identifying the effects of blast damage on structures, facilities and objects in terms of their effective use is more meaningful for survival operations purposes. Consequently, the severe and moderate damage areas have been combined into a single zone. All structures located within the zone are not usable.

Blast damage radii for various weapon sizes and types of burst, samples of idealized patterns for estimating blast damage from air and surface bursts and detailed instructions for deriving an estimate of the blast damage inflicted to various types of structures, facilities and objects will be found in the appropriate subsequent chapters.

Fire Damage

Fires, either primary or secondary, may originate in the area of blast damage. Primary fires are caused by thermal radiation; secondary fires by overturned space heaters, broken gas lines, and short-circuited electrical equipment.

Primary fires would be more numerous where light, dry, flammable materials such as combustible trash, window curtains, interior furniture and furnishings, and frayed wood shingles, are exposed. Thermal radiation may contribute to the overall damage by igniting combustible materials, e.g. finely divided or thin fuels such as dried leaves and newspapers, and thus starting fires in buildings or forests. These fires may spread rapidly among the debris produced by the blast. As regards the direct effects of thermal radiation on structures, generally speaking, they are inconsequential. Ignition of materials depends on their thickness, moisture content and temperature level at the time of a nuclear detonation. Ignition is more difficult if the material is cold than if it is hot.

Secondary fires occur principally within structures. Therefore, they are not seriously affected by moisture conditions outside. The incidence of these fires is closely related to the following:

a. type of heating and cooking equipment

b. time of day

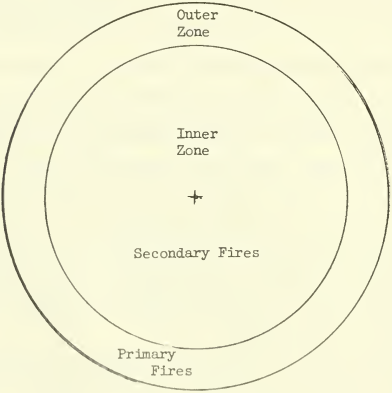
c. season of year

d. presence or absence of flammable rubbish

Mass fires, consisting of fire storms (great stationary fires which generate their own systems of in-blowing winds) and conflagrations (great fires which move along the ground under the influence of strong winds) are extremely difficult to predict, because the conditions for their occurrence are highly variable and uncertain and depend on the conditions existing at the time of the fire. For example, combustible frame buildings when blown down do not burn as rapidly as standing buildings. Also, noncombustible debris produced by the blast may cover and prevent the burning of combustible material. Consequently, methods and procedures for estimating the effects of potential mass fires - fire storms and conflagrations - have not been developed and, therefore, are not included in this document.

For estimating the extent of primary fires (ignition of fine kindling fuels) and secondary fires (started by upset stoves and furnaces, electrical short-circuits and broken gas lines), two zones, representing different distances from ground zero are depicted on the idealized pattern - an inner and outer zone. The inner zone corresponds to the blast damage inner zone and is for use in estimating extent of secondary fires; the outer zone is for use in estimating the extent of primary fires. The following schematic illustration presents the shape and depicts the two zones of the fire damage pattern:

Idealized Fire Damage Pattern

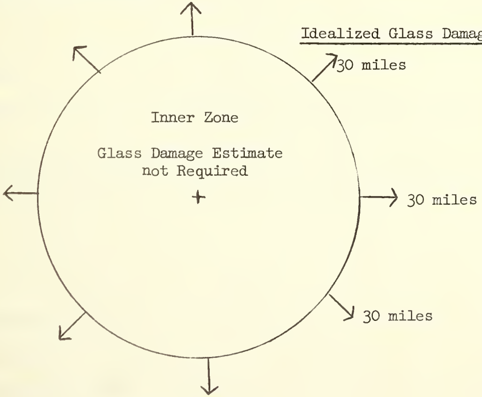


Scale - 1:250,000
1 MT - Air Burst

Glass Damage

Structures in light damaged areas will sustain broken windows. Use of these structures may require replacement of the shattered glass. Also, broken glass strewn on streets may present a hazard in conducting survival operations. Consequently, a knowledge of the extent of the area sustaining glass damage is required to assist operational personnel in preparing plans for survival operations. For estimating the extent of the glass damage, two zones representing different distances from ground zero are depicted on the idealized pattern - an inner and outer zone. The inner zone represents the area of severe and moderate damage and indicates structures therein sustained a type of damage precluding their use. Consequently, no estimate of glass damage is required. The outer zone represents the area in which structures probably sustained glass damage. The following illustration presents the shape and depicts the two zones of the glass damage pattern:

Idealized Glass Damage Pattern



Scale - 1:250,000
1 MT - Air Burst

The perimeter of the inner zone will vary with the type of construction and type of structure under consideration; the perimeter of the outer zone, however, will not vary with the type of construction of the structure under consideration. Shattering of glass, large and small, occurs when the side-on blast overpressure is between 0.5 to 1.0 psi.

The following table furnishes the radii of glass damage - the distances, in miles, from ground zero - for various weapon sizes and types of bursts. Structures located within the areas encompassed by the radii will sustain shattering of glass.

Weapon Size	Typical Air Burst Radii (mi)	Surface Burst(a) Radii (mi)
1 MT	0.0-30.0	0.0-22.5
3 MT	0.0-43.2	0.0-32.4
5 MT	0.0-51.3	0.0-38.5
10 MT	0.0-64.5	0.0-48.4
20 MT	0.0-81.3	0.0-61.0

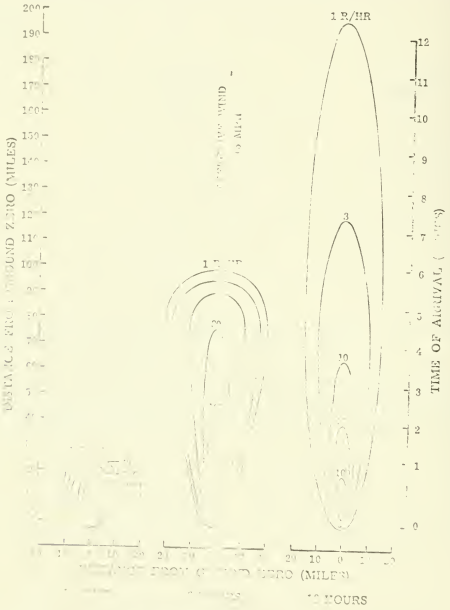
(a) For a surface burst, the damage range is three-quarters that for an air burst of the same yield.

The glass damage radii are so large that, generally speaking, weapons detonated in or near urbanized area may shatter all glass within an urbanized area.

Fallout

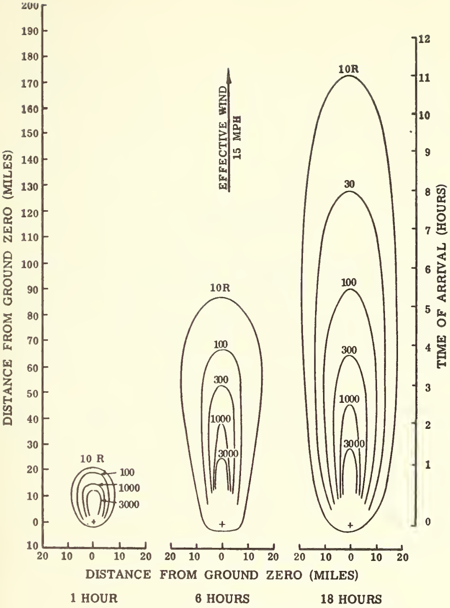
For practical and estimation purposes, it is convenient to consider the nuclear radiations as being divided into two categories - initial and residual. Initial radiation refers to the radiation emitted within one minute of the detonation; residual radiation is that which is emitted later than one minute from the instant of explosion. In general, in an air burst, initial radiation will not extend beyond the radii of severe blast damage. A separate estimate of its consequences on people is not required. In the development of the casualty multipliers, used for estimating casualties, the effects of initial radiation were considered and included. In a surface burst, however, residual radiation within the blast area and that extending beyond, dispersed in the form of fallout particles over large areas by the wind, require consideration for estimating both casualties and land area affected. Idealized casualty patterns for estimating casualties from direct and indirect effects for surface bursts as well as methods and procedures are contained in Chapter 6.

The distribution on the ground of early fallout, i.e. fallout which reaches the ground during the first 24 hours following a nuclear explosion, varies with the wind conditions, dimensions of the radioactive cloud, distribution of the radioactivity within the mushroom head, range of particle sizes, characteristics of the weapon, nature of the surface where the detonation occurs and other variable factors. These are difficult to analyze, interrelate and their effect on the distribution of fallout particles on the ground cannot be predicted. The largest particles fall to the ground from the radioactive cloud and stem shortly after the explosion and hence are found within a short distance of ground zero. Smaller particles, on the other hand, require many hours to fall to earth. During this period they are carried hundreds of miles from the burst point by the prevailing winds. Consequently, idealized fallout patterns have been developed which represent an average fallout field for a given yield and wind condition; For the idealized patterns, the actual complex wind system is replaced by an approximately equivalent "effective wind". This is taken as the mean value of the wind speed and direction from the surface to some representative level in the cloud. Also, by assuming little or no wind shear, that is, essentially no change in wind direction at different altitudes, the idealized fallout patterns have a regular cigar-like shape. The following schematic illustration depicts an idealized fallout pattern:



200
190
150
100
DISTANCE FROM GROUND ZERO (MILES)
1 R/HR
3
10
30
100
TIME OF ARRIVAL
12
11
10
9
8
7
6
4
3
2
1
0
20
10
0
DISTANCE FROM GROUND ZERO (MILES)
HOURS

[illegible] fallout at 1, 6, and 18 hours after a [illegible] 15 mph effective wind speed).



Total-dose contours from early fallout at 1, 6, and 18 hours after surface burst with 1-megaton fission yield (15 mph effective wind speed).

The patterns show a number of "contours" (or "isodose" lines) for certain (arbitrary) round-number values of the dose, as would be observed on the ground, at 1, 6 and 18 hours,respectively, after the explosion. It will be understood, of course, that the various doses change gradually from one contour line to the next. Similarly, the last contour line does not represent the limit of contamination, since the dose will continue to fall off over a greater distance.

For additional explanatory material regarding fallout deposition and other related aspects see Appendix E.

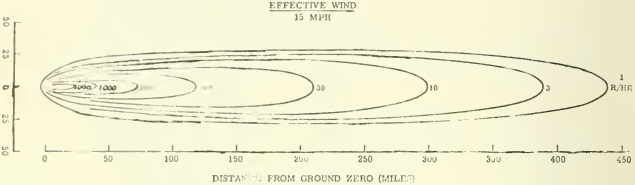


Figure 9.73. Idealized unit-time reference dose-rate pattern for early fallout from a 1-megaton fission yield surface burst (15 mph effective wind speed).

Damage Classification

For the purposes of estimation, damage to structures or objects has been divided into three categories as follows:

Severe Damage - A degree of damage that precludes further use of the structure or object for its intended purpose without essentially complete reconstruction. For a structure or building, collapse is generally implied.

Moderate Damage - A degree of damage to principal members that precludes effective use of the structure or objects for its intended purpose unless major repairs are made.

Light Damage - A degree of damage to buildings resulting in broken windows, slight damage to roofing and siding, blowing down of light interior partititions, and slight cracking of curtain walls in buildings.

The following tables furnish for various types of structures, structural elements, equipment and objects brief descriptive phrases which indicate damage type:

DAMAGE TO TYPES OF STRUCTURES PRIMARILY AFFECTED BY BLAST WAVE OVERPRESSURE DURING THE DIFFRACTION PHASE

Description of structure	Description of damage		
	Severe	Moderate	Light
Multistory reinforced concrete building with reinforced concrete walls, blast resistant design for 30 psi in Mach region from 1 MT; no windows.	Walls shattered, severe frame distortion, incipient collapse.	Walls breached or on the point of being so, frame distorted. Entranceways damaged, doors blown in or jammed, extensive spalling of concrete.	Some cracking of concrete walls and frame.
Multistory reinforced concrete building with concrete walls, small window area; 3 to 8 stories.	Walls shattered, severe frame distortion, incipient collapse.	Exterior walls badly cracked, interior partitions badly cracked or blown down. Structural frame permanently distorted, extensive spalling of concrete.	Windows and doors blown in, interior partitions cracked.
Multistory wall-bearing building, brick apartment house type; up to 3 stories.	Bearing walls collapse, resulting in total collapse of structure.	Exterior walls badly cracked, interior partitions badly cracked or blown down.	Windows and doors blown in, interior partitions cracked.
Multistory wall-bearing building, monumental type; up to 4 stories.	Bearing walls collapse, resulting in collapse of structure supported by these walls; some bearing walls may be shielded enough by intervening walls so that part of the structure may receive only moderate damage.	Exterior walls facing blast badly cracked, interior partitions badly cracked, although toward far end of building damage may be reduced.	Windows and doors blown in, interior partitions cracked.
Wood frame building, house type; 1 or 2 stories.	Frame shattered so that for the most part collapsed.	Wall framing cracked, roof badly damaged, interior partitions blown down.	Windows and doors blown in, interior partitions cracked.

DAMAGE TO TYPES OF STRUCTURES PRIMARILY AFFECTED BY DYNAMIC PRESSURE DURING THE DRAG PHASE

Description of structure	Description of damage		
	Severe	Moderate	Light
Light steel frame industrial building, single story, with up to 5 ton crane capacity. Lightweight, low strength walls fail quickly.	Severe distortion or collapse of frame.	Some to major distortion of frame, cranes (if any) not operable until repairs made.	Windows and doors blown in, light siding ripped off.
Heavy steel frame industrial building, single story, with 25-50 ton crane capacity. Lightweight, low strength walls fail quickly.	Severe distortion or collapse of frame.	Some distortion to frame, cranes not operable until repairs made.	Windows and doors blown in, light siding ripped off.
Heavy steel frame industrial building, single story, with 60-100 ton crane capacity. Lightweight, low strength walls fail quickly.	Severe distortion or collapse of frame.	Some distortion to frame, cranes not operable until repairs made.	Windows and doors blown in, light siding ripped off.
Multistory steel frame office type building, 3-10 stories (earthquake resistant construction). Lightweight, low strength walls fail quickly.	Severe frame distortion, incipient collapse.	Frame distorted moderately, interior partitions blown down.	Windows and doors blown in, light siding ripped off, interior partitions cracked.
Multistory steel frame office type building, 3-10 stories (nonearthquake resistant construction) Lightweight, low strength walls fail quickly.	Severe frame distortion, incipient collapse.	Frame distorted moderately, interior partitions blown down.	Windows and doors blown in, light siding ripped off, interior partitions cracked.
Multistory reinforced concrete frame office type building, 3-10 stories (earthquake resistant construction). Lightweight, low strength walls fail quickly.	Severe frame distortion, incipient collapse.	Frame distorted moderately, interior partitions blown down. Some spalling of concrete.	Windows and doors blown in, light siding ripped off, interior partitions cracked.
Multistory reinforced concrete frame office type building, 3-10 stories (nonearthquake resistant construction). Lightweight, low strength walls fail quickly.	Severe frame distortion, incipient collapse.	Frame distorted moderately, interior partitions blown down. Some spalling of concrete.	Windows and doors blown in, light siding ripped off, interior partitions cracked.
Highway truss bridges, spans 150-250 ft.	Total failure of lateral bracing, collapse of bridge.	Some failure of lateral bracing such that bridge capacity is reduced about 50 percent.	Capacity of bridge unchanged, slight distortion of some bridge components.
Railroad truss bridges, spans 150-250 ft.	Total failure of lateral bracing, collapse of bridge.	Some failure of lateral bracing such that bridge capacity is reduced about 50 percent.	Capacity of bridge unchanged, slight distortion of some bridge components.
Highway and railroad truss bridges, spans 250-500 ft.	Total failure of lateral bracing, collapse of bridge.	Some failure of lateral bracing such that bridge capacity is reduced about 50 percent.	Capacity of bridge unchanged, slight distortion of some bridge components.

CONDITIONS OF FAILURE OF PEAK OVERPRESSURE-SENSITIVE ELEMENTS

Structural element	Failure
Glass windows, large and small	Shattering usually, occasional frame failure.
Corrugated asbestos siding	Shattering
Corrugated steel or aluminum paneling	Connection failure followed by buckling
Brick wall panel, 8 in. or 12 in. thick (not reinforced).	Shearing and flexure failures
Wood siding panels, standard house constuction.	Usually failure occurs at the main connections allowing a whole panel to be blown in.
Concrete or cinder-block wall panels, 8 in. or 12 in. thick (not reinforced).	Shattering of the wall

DAMAGE CRITERIA FOR SHALLOW BURIED STRUCTURES

Type of structure	Damage type		Nature of damage
Light, corrugated steel arch, surface structure (10-gage corrugated steel with a span of 20–25 ft), central angle of 180° with 5 ft of earth cover at the crown.[*]	Severe		Collapse.
	Moderate		Large deformations of end walls and arch, also major entrance door damage.
	Light		Damage to ventilation and entrance door.
Buried concrete arch with a 16 ft span and central angle of 180°; 8 in. thick with 4 ft of earth cover at the crown.	Severe		Collapse.
	Moderate		Large deformations with considerable cracking and spalling.
	Light		Cracking of panels, possible entrance door damge.

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[*] In the case of arched structures reinforced with ribs, the collapse pressure is higher depending on the number of ribs.

DAMAGE CRITERIA FOR LAND TRANSPORTATION EQUIPMENT

Description of equipment	Damage	Nature of damage
Motor equipment (cars and trucks).	Severe	Gross distortion of frame, large displacements, outside appurtenances (door and hoods) torn off, need rebuilding before use.
	Moderate	Turned over and displaced, badly dented, frames sprung, need major repairs.
	Light	Glass broken, dents in body, possibly turned over, immediately usable.
Railroad rolling stock (box, flat, tank, and gondola cars).	Severe	Car blown from tracks and badly smashed, extensive distortion, some parts usable.
	Moderate	Doors demolished, body damaged, frame distorted, could possibly roll to repair shop.
	Light	Some door and body damage, car can continue in use.
Railroad locomotives (Diesel or steam).	Severe	Overturned, parts blown off, sprung and twisted, major overhaul required.
	Moderate	Probably overturned, can be towed to repair shop after being righted, need major repairs.
	Light	Glass breakage and minor damage to parts, immediately usable.
Construction equipment (bulldozers and graders).	Severe	Extensive distortion of frame amd crushing of sheet metal, extensive damage to tracks and wheels.
	Moderate	Some frame distortion, overturning, track and wheel damage.
	Light	Slight damage to cabs and housing, glass breakage.

DAMAGE CRITERIA FOR PARKED AIRCRAFT

Damage type	Nature of damage	Overpressure
Severe	Major (or depot level) maintenance required to restore aircraft to operational status.	Transport airplanes Light liaison craft Helicopters
Moderate	Field maintenance required to restore aircraft to operational status.	Transport airplanes Light liaison craft Helicopters
Light	Flight of the aircraft not prevented, although performance may be restricted.	Transport airplanes Light liaison craft Helicopters

DAMAGE CRITERIA FOR SHIPPING FROM AIR BLAST

Damage type	Nature of damage
Severe	The ship is either sunk or is damaged to the extent of requiring rebuilding.
Moderate	The ship is immobilized and requires extensive repairs, especially to shock-sensitive components or their foundations, e.g., propulsive machinery, boilers, and interior equipment.
Light	The ship may still be able to operate, although there will be damage to electronic, electrical, and mechanical equipment.

DAMAGE CRITERIA FOR FORESTS

Damage type	Nature of damage
Severe	Up to 90 percent of trees blown down; remainder denuded of branches and leaves. (Area impassable to vehicles and very difficult on foot.)
Moderate	About 30 percent of trees blown down; remainder have some branches and leaves blown off. (Area passable to vehicles only after extensive clearing.)
Light	Very few trees blown down; some leaves and branches blown off. (Area passable to vehicles.)

Chapter 6

General Methodology For Developing Estimates

Damage Vs. Resources Remaining

The application of the graphic techniques and procedures, contained in this document, will furnish estimates of casualties and damage to individual resources as well as estimates of survivors and resources remaining. The same idealized patterns are employed; however, the procedures involved differ. For developing estimates of blast damage to an individual resource, facilities located within severe and moderate damage zones only are considered. These are not usable and, therefore, not available. For developing estimates of resources remaining, the non-suable facilities may be subtracted from the total facilities under consideration. The figure derived in this manner furnishes an estimate of the resources remaining or usable facilities. An alternate and more direct procedure, however, may be employed. The procedure involves consideration of facilities located within the light damage zone and in undamaged areas only. These facilities are usable and, therefore, constitute resources remaining. Both procedures furnish the same estimates and, therefore, each analyst has the option of selecting the procedure considered most suitable.

Developing Separate Estimates for "Direct" and "Indirect" Effects

For practical purposes, it is convenient to develop separate estimates for the effects within the blast area and for the effects beyond the blast area. Direct effects, resulting from the destructive actions due to blast, shock or fire, in general, are confined to the blast area. Indirect effects, resulting from fallout deposition, extend hundreds of miles beyond the blast area.

Direct Effects

For estimating direct effects, the use of large scale maps, such as: 1:24,000 or intermediate scale maps, such as 1:250,000 or 1:500,000 are recommended. To develop estimates of the effects within the blast area, the idealized patterns for casualties, blast and fire are used. For both casualties and physical damage (blast and fire), the general estimating procedures are the same. Various types of transparent idealized pattern overlays are used - one for estimating casualties, one type for estimating blast damage and another type for estimating fire damage. In each case, the appropriate transparent overlay representing the degree of damage or the percentage of casualties or survivors in each of the areas surrounding ground zero is superimposed in turn on various maps which represent locations of significant resources or distribution of people. Damage to these resources or injuries to the people are estimated on the basis of the degree of casualty percentages indicated on the various parts of the overlay. Different overlays are used for different size bombs and types of bursts.

Indirect Effects

For estimating indirect effects, the use of small scale maps, such as 1:2,500,000 are recommended. To develop estimates of the effects beyond the blast area, idealized fallout and glass damage patterns are used. For estimating the extent of fallout deposition, dose rates and dose levels, the estimating procedures are the same. Different overlays are used for different weapon yields. The appropriate transparent overlay is superimposed on the small scale maps and is used in conjunction with tables showing dose rates and dose figures for various time periods. Appendix E furnishes detailed explanatory instructions.

Damage Concepts

When considering the estimation process, it is essential that the term "radius of damage" be thoroughly understood. "Radius of Damage" is used with respect to both people and objects. When estimating effects on people, the "radius of damage" is referred to as a "casualty radius"; when estimating effects on objects, the "radius of damage" is referred to as a "damage radius".

The definition of the radius of damage is derived from the type of damage sustained by a particular type of structure as well as the distribution of casualties and types of damage sustained by average buildings in a city in and around ground zero. The casualty radii for estimating casualties are included in Chapter 7; damage radii for use in estimating damage to individual Resources are included in the various chapters pertaining to Resources. The structural composition of various types of facilities and objects respond differently to the blast effect. Consequently, the types of damage sustained by each structural feature at the same distance from ground zero will vary. Where construction information for structures is available, the variations for structural features in the blast response, i.e. their susceptibility to damage (physical vulnerability) should be taken into consideration.

The crater radii for surface bursts have not been developed. The severe damage radii data for surface bursts include the crater effects.

Relationship of Zone of A-B-C-D-Damage to Idealized Blast Damage Patterns

In the past, for the purposes of estimating damage, it has been customary to employ four zones of damage. These were:

Zone of A-damage	buildings virtually completely destroyed
Zone of B-damage	buildings severely damaged or destroyed; buildings must be torn down
Zone of C-damage	buildings moderately or severely damage; moderately damaged buildings must be vacated for repairs
Zone of D-damage	buildings partially damaged; buildings need not be vacated during repairs

The adoption of four damage zones and identification of each zone by means of an alphabetic letter was to facilitate the identification of the types of damage inflicted by a nuclear detonation on structures. Virtually completely destroyed (zone of A-damage) and severely damaged (zone of B-damage) structures are not usable; therefore, the prior artificial distinction has been eliminated.

The following presents the relationship of the formerly employed zones of A-B-C-D-damage with the current recommended idealized blast damage pattern for use in estimating blast damage to structures:

Usability of Structure	Type of Damage	
	Current Identification	Former Identification
Not Usable	Severe	Zone of A-damage Zone of B-damage
	Moderate	Zone of C-damage
Usable	Light	Zone of D-damage

Preparation of Idealized Patterns for Estimating Direct Effects

Furnished in this document for each Resource and various types of structures and features are radii, in miles, for estimating severe, moderate and light blast damage and fire likely. In the preparation of idealized patterns to estimate direct effects it is not necessary to delineate the perimeter of severe damage. Severe and moderate damage structures are not usable for survival operations; consequently, in preparing idealized patterns, the perimeters of moderate and light blast damage and fire likely need be delineated only.

Estimating Damage (Blast and Fire) to Average Buildings

In general, an American city contains an intermingling of a variety of residential and commercial building types of structures. Plotting each type of structure on maps for estimating purposes is not always practical. It is convenient, therefore, for certain estimation purposes to employ a technique based on an "average building" concept. "Average building", as used herein, refers to ordinary types of buildings most commonly used in a typical urban complex in American cities. The types of structures are (a) conventional residential structures, such as: brick and wood frame houses and multi-story brick structures such as used for apartment houses, retail and wholesale stores and institutional buildings (b) one story steel and wall frame commercial and industrial buildings. The average building concept technique may be used for developing estimates of damage to housing as well as for developing estimates of damage to structures in general where detailed construction information is not readily available and an approximation of the types of damage sustained is desired. The blast damage radii for an air burst are based on the assumption that the height of burst is such as to maximize the distance to which each type of blast extends; in other words, the radii of the circles give the greatest ranges at which the indicated blast level will occur for any air burst of any given yield. The surface burst radii are roughly three-fourths of the air burst radii. Structures located within the inner zone, consisting of severe and moderate damage areas, are not usable; structures located within the outer zone - light damage area - are usable even though the structures sustain light damage to window frames, doors and plaster. Within the inner zone there will be a great fire hazard to structures from secondary fires; within the outer zone structures may be further damage by primary fires resulting from thermal radiation. The fire likely radii, therefore, are also furnished.

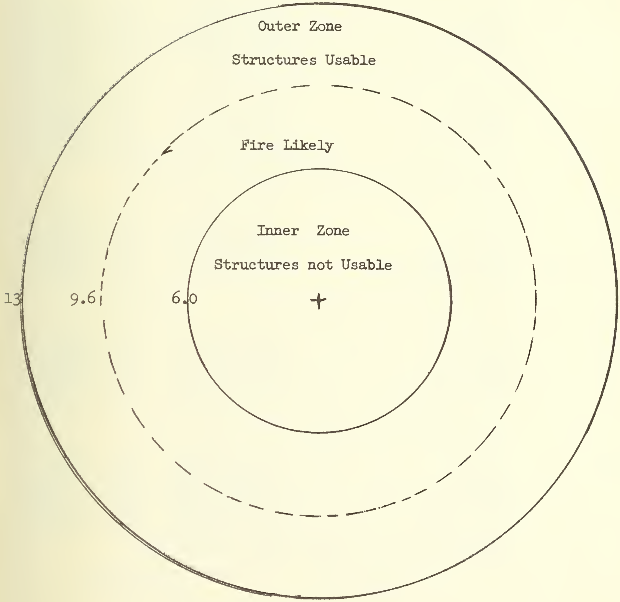
The following schematic illustration depicts the shape and boundaries of the idealized damage (blast and fire) pattern for "average buildings" for a 1 MT, air burst, scale 1:250,000:

Idealized Blast Damage Pattern

Air Burst

1 MT

(Maximized Ranges)



Scale - 1:250,000

Note: Inner zone represents areas of severe and moderate damage to structures. Outer zone represents areas of light damage to structures.

Average Buildings

Weapon Size (Megatons)	Type of Damage	Air Burst Radii (miles)	Surface Burst Radii (miles)
1 MT	Severe	0.0 - 4.5	0.0 - 3.4
	Moderate	4.5 - 6.0	3.4 - 4.5
	Light	6.0 - 13.0	4.5 - 9.8
	Fire Likely	0.0 - 9.6	0.0 - 5.3
3 MT	Severe	0.0 - 6.5	0.0 - 4.9
	Moderate	6.5 - 8.6	4.9 - 6.5
	Light	8.6 - 18.7	6.5 - 14.1
	Fire Likely	0.0 - 13.8	0.0 - 7.6
	(Derivation: 1.44 times figures for a 1 MT)		
5 MT	Severe	0.0 - 7.7	0.0 - 5.8
	Moderate	7.7 - 10.3	5.8 - 7.7
	Light	10.3 - 22.2	7.7 - 16.8
	Fire Likely	0.0 - 16.4	0.0 - 9.1
	(Derivation: 1.71 times figures for a 1 MT)		
10 MT	Severe	0.0 - 9.7	0.0 - 7.3
	Moderate	9.7 - 12.9	7.3 - 9.7
	Light	12.9 - 28.0	9.7 - 21.1
	Fire Likely	0.0 - 20.6	0.0 - 11.4
	(Derivation: 2.15 times figures for a 1 MT)		
20 MT	Severe	0.0 - 12.2	0.0 - 9.2
	Moderate	12.2 - 16.3	9.2 - 12.2
	Light	16.3 - 35.2	12.2 - 26.6
	Fire Likely	0.0 - 26.0	0.0 - 14.4
	(Derivation: 2.71 times figures for a 1 MT)		

Table 6-1

Estimating Damage to Particular Types of Buildings

Where detailed information regarding the construction of a structure is available, the damage radii for the type of structure under consideration may be employed for estimation purposes. Damage radii for air and surface bursts for various types of structures used for residential, institutional, commercial and industrial purposes have been developed and are contained in Tables ________. Radii for the following types of structures have been developed:

Residential and Institutional

a. Wood frame
b. Wall-bearing - 2 story
c. Wall-bearing - 3 to 5 story (apartment house type)

Commercial

a. Wall-bearing - 2 story
b. Wall-bearing (monumental type) - multi-story
c. Steel frame - conventional design
d. Steel frame - multi-story
e. Reinforced concrete (conventional) - multi-story
f. Reinforced concrete frame - multi-story

Industrial

a. Light steel frame
b. Heavy steel frame - 25 to 50 ton crane
c. Heavy steel frame - 60 to 100 ton crane

Buildings

Residential

Wood Frame

Weapon Size (Megatons)	Type of Damage	Air Burst Radii (miles)	Surface Burst Radii (miles)
1 MT	Severe	0.0 - 5.8	0.0 - 4.5
	Moderate	5.8 - 6.8	4.5 - 5.2
	Light	6.8 - 10.0	5.2 - 8.8
	Fire Likely	0.0 - 9.6	0.0 - 5.3
3 MT	Severe	0.0 - 8.4	0.0 - 6.5
	Moderate	8.4 - 9.8	6.5 - 7.5
	Light	9.8 - 14.4	7.5 - 12.7
	(Derivation: 1.44 times figures for a 1 MT)		
5 MT	Severe	0.0 - 9.9	0.0 - 7.8
	Moderate	9.9 - 11.6	7.8 - 8.9
	Light	11.6 - 17.1	8.9 - 15.0
	Fire Likely	0.0 - 16.4	0.0 - 9.1
	(Derivation: 1.71 times figures for a 1 MT)		
10 MT	Severe	0.0 - 12.5	0.0 - 9.7
	Moderate	12.5 - 14.6	9.7 - 11.2
	Light	14.6 - 21.5	11.2 - 18.9
	Fire Likely	0.0 - 20.6	0.0 - 11.4
	(Derivation: 2.15 times figures for a 1 MT)		
20 MT	Severe	0.0 - 15.7	0.0 - 12.2
	Moderate	15.7 - 18.4	12.2 - 14.1
	Light	18.4 - 27.1	14.1 - 23.8
	Fire Likely	0.0 - 26.0	0.0 - 14.4
	(Derivation: 2.71 times figures for a 1 MT)		

Table 6-2

Building

Residential

Wall-bearing - 2 Story

Weapon Size (Megatons)	Type of Damage	Air Burst Radii (miles)	Surface Burst Radii (miles)
1 MT	Severe	0.0 - 3.9	0.0 - 3.0
	Moderate	3.9 - 5.2	3.0 - 4.0
	Light	5.2 - 10.0	4.0 - 8.8
	Fire Likely	0.0 - 9.6	0.0 - 5.3
3 MT	Severe	0.0 - 5.6	0.0 - 4.3
	Moderate	5.6 - 7.5	4.3 - 5.8
	Light	7.5 - 14.4	5.8 - 12.7
	Fire Likely	0.0 - 13.8	0.0 - 7.6
	(Derivation: 1:44 times figures for a 1 MT)		
5 MT	Severe	0.0 - 6.7	0.0 - 5.1
	Moderate	6.7 - 8.9	5.1 - 6.8
	Light	8.9 - 17.1	6.8 - 15.0
	Fire Likely	0.0 - 16.4	0.0 - 9.1
	(Derivation: 1.71 times figures for a 1 MT)		
10 MT	Severe	0.0 - 8.4	0.0 - 6.5
	Moderate	8.4 - 11.2	6.5 - 8.6
	Light	11.2 - 21.5	8.6 - 18.9
	Fire Likely	0.0 - 20.6	0.0 - 11.4
	(Derivation: 2.15 times figures for a 1 MT)		
20 MT	Severe	0.0 - 10.6	0.0 - 8.1
	Moderate	10.6 - 14.1	8.1 - 10.8
	Light	14.1 - 27.1	10.8 - 23.8
	Fire Likely	0.0 - 26.0	0.0 - 14.4
	(Derivation: 2.71 times figures for a 1 MT)		

Table 6-3

Building

Residential

Wall-bearing - 3 to 5 Story

(Apartment House Type)

Weapon Size (Megatons)	Type of Damage	Air Burst Radii (miles)	Surface Burst Radii (miles)
1 MT	Severe	0.0 - 3.2	0.0 - 2.4
	Moderate	3.2 - 3.9	2.4 - 3.0
	Light	3.9 - 10.0	3.0 - 8.8
	Fire Likely	0.0 - 9.6	0.0 - 5.3
3 MT	Severe	0.0 - 4.6	0.0 - 3.5
	Moderate	4.6 - 5.6	3.5 - 4.3
	Light	5.6 - 14.4	4.3 - 12.7
	Fire Likely	0.0 - 13.8	0.0 - 7.6

(Derivation: 1.44 times figures for a 1 MT)

Weapon Size (Megatons)	Type of Damage	Air Burst Radii (miles)	Surface Burst Radii (miles)
5 MT	Severe	0.0 - 5.5	0.0 - 4.1
	Moderate	5.5 - 6.7	4.1 - 5.1
	Light	6.7 - 17.1	5.1 - 15.0
	Fire Likely	0.0 - 16.4	0.0 - 9.1

(Derivation: 1.71 times figures for a 1 MT)

Weapon Size (Megatons)	Type of Damage	Air Burst Radii (miles)	Surface Burst Radii (miles)
10 MT	Severe	0.0 - 6.9	0.0 - 5.2
	Moderate	6.9 - 8.4	5.2 - 6.5
	Light	8.4 - 21.5	6.5 - 18.9
	Fire Likely	0.0 - 20.6	0.0 - 11.4

(Derivation: 2.15 times figures for a 1 MT)

Weapon Size (Megatons)	Type of Damage	Air Burst Radii (miles)	Surface Burst Radii (miles)
20 MT	Severe	0.0 - 8.7	0.0 - 6.5
	Moderate	8.7 - 10.6	6.5 - 8.0
	Light	10.6 - 27.1	8.0 - 23.8
	Fire Likely	0.0 - 26.0	0.0 - 14.4

(Derivation: 2.71 times figures for a 1 MT)

Table 6-4

Building

Commercial

2 Story - Wall-bearing

Weapon Size (Megatons)	Type of Damage	Air Burst Radii (miles)	Surface Burst Radii (miles)
1 MT	Severe	0.0 - 3.5	0.0 - 2.6
	Moderate	3.5 - 4.5	2.6 - 3.4
	Light	4.5 - 10.0	3.4 - 8.8
	Fire Likely	0.0 - 9.6	0.0 - 5.3
3 MT	Severe	0.0 - 5.0	0.0 - 3.7
	Moderate	5.0 - 6.5	3.7 - 4.9
	Light	6.5 - 14.4	4.9 - 12.7
	Fire Likely	0.0 - 13.8	0.0 - 7.6
	(Derivation: 1.44 times figures for a 1 MT)		
5 MT	Severe	0.0 - 6.0	0.0 - 4.4
	Moderate	6.0 - 7.8	4.4 - 5.8
	Light	7.8 - 17.1	5.8 - 15.0
	Fire Likely	0.0 - 16.4	0.0 - 9.1
	(Derivation: 1.71 times figures for a 1 MT)		
10 MT	Severe	0.0 - 7.5	0.0 - 5.6
	Moderate	7.5 - 9.7	5.6 - 7.3
	Light	9.7 - 21.5	7.3 - 18.9
	Fire Likely	0.0 - 20.6	0.0 - 11.4
	(Derivation: 2.15 times figures for a 1 MT)		
20 MT	Severe	0.0 - 9.5	0.0 - 7.0
	Moderate	9.5 - 12.2	7.0 - 9.2
	Light	12.2 - 27.1	9.2 - 23.8
	Fire Likely	0.0 - 26.0	0.0 - 14.4
	(Derivation: 2.71 times figures for a 1 MT)		

Table 6-5

Building

Commercial - Office

Multi-story - Wall bearing Monumental

Weapon Size (Megatons)	Type of Damage	Air Burst Radii (miles)	Surface Burst Radii (miles)
1 MT	Severe	0.0 - 1.2	0.0 - 1.6
	Moderate	1.2 - 2.2	1.6 - 1.9
	Light	2.2 - 10.0	1.9 - 8.8
	Fire Likely	0.0 - 9.6	0.0 - 5.3
3 MT	Severe	0.0 - 1.7	0.0 - 2.3
	Moderate	1.7 - 3.2	2.3 - 2.7
	Light	3.2 - 14.4	2.7 - 12.7
	Fire Likely	0.0 - 13.8	0.0 - 7.6
	(Derivation: 1.44 times figures for a 1 MT)		
5 MT	Severe	0.0 - 2.1	0.0 - 2.7
	Moderate	2.1 - 3.8	2.7 - 3.2
	Light	3.8 - 17.1	3.2 - 15.0
	Fire Likely	0.0 - 16.4	0.0 - 9.1
	(Derivation: 1.71 times figures for a 1 MT)		
10 MT	Severe	0.0 - 2.6	0.0 - 3.4
	Moderate	2.6 - 4.7	3.4 - 4.1
	Light	4.7 - 21.5	4.1 - 18.9
	Fire Likely	0.0 - 20.6	0.0 - 11.4
	(Derivation: 2.15 times figures for a 1 MT)		
20 MT	Severe	0.0 - 3.3	0.0 - 4.3
	Moderate	3.3 - 6.0	4.3 - 5.1
	Light	6.0 - 27.1	5.1 - 23.8
	Fire Likely	0.0 - 26.0	0.0 - 14.4
	(Derivation: 2.71 times figures for a 1 MT)		

Table 6-6

Building

Commercial

Steel Frame - Conventional Design

Weapon Size (Megatons)	Type of Damage	Air Burst Radii (miles)	Surface Burst Radii (miles)
1 MT	Severe	0.0 - 1.7	0.0 - 1.6
	Moderate	1.7 - 2.4	1.6 - 1.9
	Light	2.4 - 10.0	1.9 - 8.8
	Fire Likely	0.0 - 9;6	0.0 - 5.3
3 MT	Severe	0.0 - 2.4	0.0 - 2.3
	Moderate	2.4 - 3.5	2.3 - 2.7
	Light	3.5 - 14.4	2.7 - 12.7
	Fire Likely	0.0 - 13.8	0.0 - 7.6
	(Derivation: 1.44 times figures for a 1 MT)		
5 MT	Severe	0.0 - 2.9	0.0 - 2.7
	Moderate	2.9 - 4.1	2.7 - 3.2
	Light	4.1 - 17.1	3.2 - 15.0
	Fire Likely	0.0 - 16.4	0.0 - 9.1
	(Derivation: 1.71 times figures for a 1 MT)		
10 MT	Severe	0.0 - 3.7	0.0 - 3.4
	Moderate	3.7 - 5.2	3.4 - 4.1
	Light	5.2 - 21.5	4.1 - 18.9
	Fire Likely	0.0 - 20.6	0.0 - 11.4
	(Derivation: 2.15 times figures for a 1 MT)		
20 MT	Severe	0.0 - 4.6	0.0 - 4.3
	Moderate	4.6 - 6.5	4.3 - 5.1
	Light	6.5 - 27.1	5.1 - 23.8
	Fire Likely	0.0 - 26.0	0.0 - 14.4
	(Derivation: 2.71 times figures for a 1 MT)		

Table 6-7

Building

Commercial

Multi-story - Steel Frame

Weapon Size (Megatons)	Type of Damage	Air Burst Radii (miles)	Surface Burst Radii (miles)
1 MT	Severe	0.0 - 1.7	0.0 - 1.6
	Moderate	1.7 - 2.4	1.6 - 1.9
	Light	2.4 - 10.0	1.9 - 8.8
	Fire Likely	0.0 - 9.6	0.0 - 5.3
3 MT	Severe	0.0 - 2.4	0.0 - 2.3
	Moderate	2.4 - 3.5	2.3 - 2.7
	Light	3.5 - 14.4	2.7 - 12.7
	Fire Likely	0.0 - 13.8	0.0 - 7.6
	(Derivation: 1.44 times figures for a 1 MT)		
5 MT	Severe	0.0 - 2.9	0.0 - 2.7
	Moderate	2.9 - 4.1	2.7 - 3.2
	Light	4.1 - 17.1	3.2 - 15.0
	Fire Likely	0.0 - 16.4	0.0 - 9.1
	(Derivation: 1.71 times figures for a 1 MT)		
10 MT	Severe	0.0 - 3.7	0.0 - 3.4
	Moderate	3.7 - 5.2	3.4 - 4.1
	Light	5.2 - 21.5	4.1 - 18.9
	Fire Likely	0.0 - 20.6	0.0 - 11.4
	(Derivation: 2.15 times figures for a 1 MT)		
20 MT	Severe	0.0 - 4.6	0.0 - 4.3
	Moderate	4.6 - 6.5	4.3 - 5.1
	Light	6.5 - 27.1	5.1 - 23.8
	Fire Likely	0.0 - 26.0	0.0 - 14.4
	(Derivation: 2.71 times figures for a 1 MT)		

Table 6-8

Building

Commercial

Reinforced Concrete - Conventional

Weapon Size (Megatons)	Type of Damage	Air Burst Radii (miles)	Surface Burst Radii (miles)
1 MT	Severe	0.0 - 1.4	0.0 - 1.4
	Moderate	1.4 - 1.7	1.4 - 1.6
	Light	1.7 - 10.0	1.6 - 8.8
	Fire Likely	0.0 - 9.6	0.0 - 5.3
3 MT	Severe	0.0 - 2.0	0.0 - 2.0
	Moderate	2.0 - 2.4	2.0 - 2.3
	Light	2.4 - 14.4	2.3 - 12.7
	Fire Likely	0.0 - 13.8	0.0 - 7.6
	(Derivation: 1.44 times figures for a 1 MT)		
5 MT	Severe	0.0 - 2.4	0.0 - 2.4
	Moderate	2.4 - 2.9	2.4 - 2.7
	Light	2.9 - 17.1	2.7 - 15.0
	Fire Likely	0.0 - 16.4	0.0 - 9.1
	(Derivation: 1.71 times figures for a 1 MT)		
10 MT	Severe	0.0 - 3.0	0.0 - 3.0
	Moderate	3.0 - 3.7	3.0 - 3.4
	Light	3.7 - 21.5	3.4 - 18.9
	Fire Likely	0.0 - 20.6	0.0 - 11.4
	(Derivation: 2.15 times figures for a 1 MT)		
20 MT	Severe	0.0 - 3.8	0.0 - 3.8
	Moderate	3.8 - 4.6	3.8 - 4.3
	Light	4.6 - 27.1	4.3 - 23.8
	Fire Likely	0.0 - 26.0	0.0 - 14.4
	(Derivation: 2.71 times figures for a 1 MT)		

Table 6-9

Building

Commercial

Multi-story - Reinforced Concrete - Frame

Weapon Size (Megatons)	Type of Damage	Air Burst Radii (miles)	Surface Burst Radii (miles)
1 MT	Severe	0.0 - 1.4	0.0 - 1.4
	Moderate	1.4 - 1.7	1.4 - 1.6
	Light	1.7 - 10.0	1.6 - 8.8
	Fire Likely	0.0 - 9.6	0.0 - 5.3
3 MT	Severe	0.0 - 2.0	0.0 - 2.0
	Moderate	2.0 - 2.4	2.0 - 2.3
	Light	2.4 - 14.4	2.3 - 12.7
	Fire Likely	0.0 - 13.8	0.0 - 7.6
	(Derivation: 1.44 times figures for a 1 MT)		
5 MT	Severe	0.0 - 2.4	0.0 - 2.4
	Moderate	2.4 - 2.9	2.4 - 2.7
	Light	2.9 - 17.1	2.7 - 15.0
	Fire Likely	0.0 - 16.4	0.0 - 9.1
	(Derivation: 1.71 times figures for a 1 MT)		
10 MT	Severe	0.0 - 3.0	0.0 - 3.0
	Moderate	3.0 - 3.7	3.0 - 3.4
	Light	3.7 - 21.5	3.4 - 18.9
	Fire Likely	0.0 - 20.6	0.0 - 11.4
	(Derivation: 2.15 times figures for a 1 MT)		
20 MT	Severe	0.0 - 3.8	0.0 - 3.8
	Moderate	3.8 - 4.6	3.8 - 4.3
	Light	4.6 - 27.1	4.3 - 23.8
	Fire Likely	0.0 - 26.0	0.0 - 14.4
	(Derivation: 2.71 times figures for a 1 MT)		

Table 6-10

Building

Industrial

Light Steel Frame

Weapon Size (Megatons)	Type of Damage	Air Burst Radii (miles)	Surface Burst Radii (miles)
1 MT	Severe	0.0 - 2.8	0.0 - 2.1
	Moderate	2.8 - 3.5	2.1 - 2.7
	Light	3.5 - 10.0	0.0 - 5.3
	Fire Likely	0.0 - 9.6	0.0 - 5.3
3 MT	Severe	0.0 - 4.0	0.0 - 3.0
	Moderate	4.0 - 5.0	3.0 - 3.8
	Light	5.0 - 14.4	3.8 - 12.7
	Fire Likely	0.0 - 13.8	0.0 - 7.6

(Derivation: 1.44 times figures for a 1 MT)

5 MT	Severe	0.0 - 4.8	0.0 - 3.6
	Moderate	4.8 - 6.0	3.6 - 4.5
	Light	0.0 - 17.1	4.5 - 15.0
	Fire Likely	0.0 - 16.4	0.0 - 9.1

(Derivation: 1.71 times figures for a 1 MT)

10 MT	Severe	0.0 - 6.0	0.0 - 4.5
	Moderate	6.0 - 7.5	4.5 - 5.8
	Light	7.5 - 21.5	5.8 - 18.9
	Fire Likely	0.0 - 20.6	0.0 - 11.4

(Derivation: 2.15 times figures for a 1 MT)

20 MT	Severe	0.0 - 7.6	0.0 - 5.6
	Moderate	7.6 - 9.5	5.6 - 7.3
	Light	9.5 - 27.1	7.3 - 23.8
	Fire Likely	0.0 - 26.0	0.0 - 14.4

(Derivation: 2.71 times figures for a 1 MT)

Table 6-11

BUILDING

Industrial

Heavy Steel Frame (25 to 50 Ton Crane)

Weapon Size (Megatons)	Type of Damage	Air Burst Radii (miles)	Surface Burst Radii (miles)
1 MT	Severe	0.0 - 2.4	0.0 - 1.8
	Moderate	2.4 - 3.2	1.8 - 2.4
	Light	3.2 - 10.0	2.4 - 8.8
	Fire Likely	0.0 - 9.6	0.0 - 5.3
3 MT	Severe	0.0 - 3.5	0.0 - 2.6
	Moderate	3.5 - 4.6	2.6 - 3.5
	Light	4.6 -14.4	3.5 - 12.7
	Fire Likely	0.0 - 13.8	0.0 - 7.6
	(Derivation: 1.44 times figures for a 1 MT)		
5 MT	Severe	0.0 - 4.2	0.0 - 3.1
	Moderate	4.2 - 5.7	3.1 - 4.1
	Light	5.7 -17.1	4.1 -15.0
	Fire Likely	0.0 - 16.4	0.0 - 9.1
	(Derivation: 1.71 times figures for a 1 MT)		
10 MT	Severe	0.0 - 5.2	0.0 - 3.9
	Moderate	5.2 - 6.9	3.9 - 5.2
	Light	6.9 -21.5	5.2 -18.9
	Fire Likely	0.0 - 20.6	0.0 -11.4
	(Derivation: 2.15 times figures for a 1 MT)		
20 MT	Severe	0.0 - 6.5	0.0 - 4.9
	Moderate	6.5 - 8.7	4.9 - 6.5
	Light	8.7 -27.1	6.5 - 23.8
	Fire Likely	0.0 -26.0	0.0 - 14.4
	(Derivation: 2.71 times figures for a 1 MT)		

Table 6-12

Building

Industrial

Heavy Steel Frame (60 to 100 Ton Crane)

Weapon Size (Megatons)	Type of Damage	Air Burst Radii (miles)	Surface Burst Radii (miles)
1 MT	Severe	0.0 - 2.1	0.0 - 1.6
	Moderate	2.1 - 2.6	1.6 - 1.9
	Light	2.6 - 10.0	1.9 - 8.8
	Fire Likely	0.0 - 9.6	0.0 - 5.3
3 MT	Severe	0.0 - 3.0	0.0 - 2.3
	Moderate	3.0 - 3.7	2.3 - 2.8
	Light	3.7 -14.4	2.8 - 12.7
	Fire Likely	0.0 - 13.8	0.0 - 7.6
	(Derivation: 1.44 times figures for a 1 MT)		
5 MT	Severe	0.0 - 3.6	0.0 - 2.7
	Moderate	3.6 - 4.4	2.7 - 3.6
	Light	4.4 -17.1	3.6 - 15.0
	Fire Likely	0.0 -16.4	0.0 - 9.1
	(Derivation: 1.71 times figures for a 1 MT)		
10 MT	Severe	0.0 - 4.5	0.0 - 3.4
	Moderate	4.5 - 5.6	3.4 - 4.2
	Light	5.6 -21.5	4.2 - 18.9
	Fire Likely	0.0 -20.6	0.0 - 11.4
	(Derivation: 2.15 times figures for a 1 MT)		

Table 6-13

20 MT to be inserted

The damage radii are based on a combination of the information collected after the explosions in Japan and the data obtained at various nuclear tests with a theoretical analysis of loading and response to blast taken into consideration.

The purpose of developing and furnishing damage radii for various types of structures is to enable civil defense organizations to develop estimates for urban features such as:

> churches - schools - neighborhood shopping centers -
> motion picture theaters - hospitals - nursing homes -
> welfare institutions - police and fire stations -
> retail and wholesale stores - department stores - financial
> institutions - office and industrial buildings - public
> buildings - hotels and motels - garages - warehouses -
> nursing homes - homes for children and aged - convents -
> monasteries - and so forth.

In estimating direct effects to individual types of structures, a separate idealized pattern has to be prepared for each type of structure under consideration.

Estimating Thermal Damage

Blast is responsible for most of the destruction caused by a nuclear air or surface detonation. However, fires originating from ignition of combustible materials by direct thermal radiation will contribute to the overall damage. Thermal radiation also inflicts burn injuries to people. First and second degree burns produce casualties. This aspect of the effects of thermal radiation is discussed in Chapter 7.

Thermal damage results from "primary (or direct) first" initiated by the ignition of finely divided or thin fuels, such as: newspapers and dried leaves and thus starting fires in buildings or forests. The radii of thermal ignition for specific objects are derived from the distances at which the ignition energy (calcm) would initiate ignition. Each type of fabric, household material and dry forest fuel requires a different ignition energy. The distances (or radii) therefore, at which ignition occurs differ. It is not practical to plot the specific locations of the various types of fabrics, household materials and dry forest fuels. In estimating thermal damage, therefore, it has been customary to employ the concept of fires initiated under average conditions. This eliminates the preparation of a multitude of maps and thermal damage templates.

The radius of thermal ignition for fires initiated under average conditions is derived from the distance at which a specific calories per square centimeter is expected to ignite various combustible fuels, particularly newspapers. The specific calories per square centimeter used for weapon size 1 MT thru 20 MT are:

5 cal/sq cm - 1 MT

6 cal/sq cm - 3 MT and 5 MT

7 cal/sq cm - 10 MT and 20 MT

The following furnishes the radii for fires initiated by thermal radiation:

Weapons Size	Air Burst Radii (mi.)	Surface Burst Radii (mi.)
1 MT	0.0 - 11.0	0.0 - 6.6
3 MT	0.0 - 18.0	0.0 - 10.8
5 MT	0.0 - 22.0	0.0 - 13.2
10 MT	0.0 - 31.0	0.0 - 18.6
20 MT	0.0 - 42.0	0.0 - 25.2

Remarks:
1. Criteria - 5 calories/square centimeter
2. Assumptions: Average conditions and reasonably clear state of atmosphere-visibility of 10 miles or more
3. A layer of dense cloud or smoke will decrease
4. Surface burst radii scaled down to 60 percent of air burst

Although the phenomena of a blast wind is associated with nuclear detonations, the "Effects of Nuclear Weapons" states in par. 7.60, pg. 343, "the general conclusion is that the blast wind has no significant effect in extinguishing fires".

Developing Estimates for Local, State and OCD Regional Use

Application of the techniques and procedures contained in this document should enable each level of government -- local, State, OCD Region -- to develop initial estimates for various types of information required for post attack purposes. Use of maps and damage templates permit the development of varied qualitative, quantitative and distribution types of estimates as well as graphic presentations of the areas affected by blast, thermal and fallout. The distinctions between qualitative, quantitative and distribution types of estimates are as follows:

a. qualitative estimates furnish information as to type or kind rather than amount, e.g. types of casualties: killed, injured, uninjured; types of blast damage: severe, moderate, slight.

b. quantitative estimates furnish information as to amount or size, e.g. 50 or 50 percent of 100 installations severely damaged.

c. distribution estimates furnish information as to apportionment. Geographical distributions emphasize apportionments by location; qualitative distributions emphasize apportionments by type of damage, e.g. types of casualties or types of blast damage.

Other additional types of estimates that may be developed are:

a. individual estimates; e.g. blast effect on each facility within a Resource Category

b. total or aggregate estimates; e.g. an estimate for an entire geographic area -- city, State, OCD Region or for an entire Resource Category, e.g. Food, Transportation, Communications Total or aggregate estimates furnish information regarding size or magnitude.

Each level should determine its requirements and develop the types of estimates suitable to its needs as well as those required at a higher echelon.

In general, local levels require detailed types of information; State and OCD Regions require summary types of information. Local levels require for post attack purposes the following:

a. estimates for individual facilities

b. estimates for the entire area - totals or aggregates for population and each Resource Category for an understanding of the magnitude of the problems involved and for submittal to higher echelons

c. a visual depiction of the distribution of casualties and damage with their geographic area. A knowledge of the locations are essential for planning tactical operations.

States require for post attack purposes the following:

a. estimates for each State installation

b. estimates for the entire State - totals or aggregates for population and each Resource Category for an understanding of the magnitude of the problems involved and for submittal to OCD Region

c. Estimates for each county or city - totals or aggregates for population and each Resource Category for an understanding of the post attack situation within each county and city

d. a visual depiction of the geographic distribution of blast, thermal and fallout effects for a knowledge of the locations of areas affected

OCD Regions require for post attack purposes the following:

a. estimates for the entire Region - totals and aggregates for population and each Resource Category for an understanding of the magnitude of the Regional problems and for submittal to OCD Headquarters

b. estimates for each State - totals or aggregates for population and each Resource Category for an understanding of the post attack situation within each State

c. a visual depiction of the geographic distribution of blast, thermal and fallout effects for a knowledge of the locations of areas affected

Estimates for "direct" (blast area) and "indirect" (fallout area) effects should be developed by each echelon -- local, State, OCD Region -- as required. The need for detailed information, such as required by local levels, necessitates developing estimates for direct effects. The need for summary types of information, such as required by State and OCD Regions, necessitates developing estimates for indirect effects and obtaining direct effects information from lower echelons. Detailed information on field installations - State or Federal - will necessitate developing estimates from direct effects.

Assignment of Estimation Responsibilities

At State and local levels the estimation process can be accomplished most effectively and efficiently by assigning to the regular departments of government responsibilities for developing damage assessment estimates for resources relating to their established functional roles and capabilities. At the Federal level, the emergency preparedness function of damage assessment has been assigned, through executive orders, to the various Federal departments and agencies (see Appmeix F). In general, the types of activities assigned include the following:

a. maintain a capability to assess the effects of attack
    (1) on assigned resource areas, products, producing facilities and so forth
    (2) on departmental installations both at national and field levels

b. provide data to the Department of Defense

The following identifies the areas of damage assessment responsibilities assigned each department and agency at the federal level:

a. Department of Defense

Develop plans and operate systems to undertake a nationwide postattack assessment of the nature and extent of the damage and surviving resources resulting from enemy attack.

Develop plans and operate systems to monitor and report specific hazards resulting from the detonation or use of special weapons.

Report nuclear detonation information - ground zero, yield, type of burst

Delineate areas of fallout deposition

Assess population, military installations, equipment, supplies and personnel

b. General Service Administration

   (1) National government facilities - headquarters and field

   (2) Strategic and critical materials

c. Department of Labor

   (1) Departmental installations - national and field levels

   (2) State Employment Security facilities

   (3) Manpower

d. Department of Health, Education and Welfare

   (1) Departmental installations - national and field levels

   (2) Hospitals, State and Local Health departments and clinics

   (3) Health manpower

   (4) State and local welfare offices

   (5) Primary and Secondary schools and institutions of higher learning

   (6) Water systems - large and small

e. Post Office Department

Post office facilities and personnel

f. Federal Communications Commission

AM, FM and TV Radio broadcast stations and CONELRAD radio stations

g. Federal Power Commission

Facilities under their jurisdiction, electric generating stations and electric transformer substations

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   (3) Manpower

d. Department of Health, Education and Welfare

   (1) Departmental installations - national and field levels

   (2) Hospitals, State and Local Health departments and clinics

   (3) Health manpower

   (4) State and local welfare offices

   (5) Primary and Secondary schools and institutions of higher learning

   (6) Water systems - large and small

e. Post Office Department

   Post office facilities and personnel

f. Federal Communications Commission

   AM, FM and TV Radio broadcast stations and CONELRAD radio stations

g. Federal Power Commission

   Facilities under their jurisdiction, electric generating stations and electric transformer substations

h. Department of Interior

(1) Departmental installations - national and field level

(2) Major oil fields, oil refineries, crude oil and petroleum products pipelines

(3) Natural gasoline and cycle plants and natural gas pipelines

(4) Coke, and coal - bituminous, lignite, anthracite

(5) Minerals and metals (primary production)

i. Department of Commerce

Maritime Administration

Port facilities, emergency anchorage, reserve fleet, repair and shipbuilding yards

Bureau of Public Roads

Major highway bridges

Bureau of Census

Departmental installations - national and field level

Large manufacturing plants

Manufacturing plants producing survival items:
- Health supplies and equipment
- Body protection and household operation
- Light, power and fuel
- Sanitation and Water supply
- Emergency housing and lodging

Business Defense Service Administration

Special products capacity - industrial evaluation board (IEB)

j. Atomic Energy Commission

AEC facilities and suppliers

k. Federal Reserve Board

Federal reserve and commercial banking systems

l. Federal Home Loan Bank Board

Savings and Loan Associations

m. Interstate Commerce Commission

(1) Inland waterways

(2) Railroad facilities, bridges, tunnels, classification yards, repair shops, rolling stock

(3) Public warehouses

(4) Motor trucks

n. Federal Aviation Agency

Civil airports and air navigation aids

o. Department of Agriculture

(1) Grain storage

(2) Land acreage by use

(3) Farms by type of farming

(4) Livestock on Farms

(5) Crops products harvested

(6) Tobacco allotment acreage

(7) Food processing and storage capacity

p. Housing and Home Finance Agency

Housing resources

q. Veterans Administration

Facilities under their jurisdiction

Chapter 7

Population and Manpower

Scope

Elements of information essential for developing estimates of the effects of a nuclear detonation on the population are:

a. resident and/or day population figures for the geographic area for which casualty estimates are desired

b. distribution of the population depicted graphically on a map

c. survivor and casualty multipliers for use in developing casualty estimates

d. attack analysis information - time of explosion, location of ground zero, yield of weapon, type of burst, fallout pattern information

e. procedures and techniques for performing the individual tasks involved for developing the estimates.

Included in this chapter, therefore, will be found instructional material, which personnel may apply, for developing estimates of survivors and casualties following a nuclear detonation.

Purpose

Estimates of survivors and casualties are essential for immediate postattack operations, survival and recovery planning purposes. Survivor estimates are used as a basis for developing preliminary estimates of requirements for food, water, housing, fuel and other types of needs essential for survival of the population remaining after a nuclear detonation. Casualty estimates are used as a basis for developing estimates of medical needs for life-saving purposes.

Definitions

Generic words are susceptible to varied interpretations and may result in misunderstanding between individuals. Consequently, the words "population" and "manpower", as used herein for civil defense purposes, are defined and explained. "Population" refers to all human beingslocated within a specified geographic area. All persons or individuals, regardless of age, race, sex, nationality or any other population characteristic, are included under the general heading of "population". Survivor and casualty estimates for specific characteristics of the population, such as: sex, age, race and so forth, in general, are not developed for civil defense purposes. However, for manpower planning purposes, personnel may develop estimates for selected elements and occupational groups of the population. These are: existing sources of manpower (labor force), potential sources of manpower, e.g. students and teachers at institutions of higher education and specific types of skills considered essential for postattack operations purposes, i.e. doctors, dentists, nurses and so forth. For civil defense purposes, manpower refers to that portion of the people in any given geographic area available and able to work.

Information Requirements

Population Data

Essential for casualty estimation purposes are the availability of total and distribution population figures for the geographic area under consideration. For estimation purposes, resident instead of night population figures, which include transients in hotels and other minor population elements, should be used. Night population figures are not available and must be specially prepared; resident population figures may be obtained in printed form from the Bureau of Census. Although the distribution of the night population may differ from the distribution of the resident population, in general, the total night population figures do not differ markedly from the total resident population figures. The difference between the resident and night total population figures for a city, based on an analysis of a number of sample cities, is approximately $\frac{1}{2}$ of 1 percent.

Day population figures are not collected by the Bureau of Census and, therefore, are not available. If day population estimates are desired, they must be specially developed. The day population of the city proper, the part within the corporate limits, is as a rule notably larger than the resident population. The median difference between resident and day populations is approximately 20 percent. For some cities, the day population of the central area of greatest population density may be 10 times as great as the resident population of the same area, reflecting daily migrations into the city and within the city. The day population of individual census tracts in the commercial cores of some cities may be more than 80 times as large as the resident population. The day populations of most suburban tracts, in general, are less than resident populations and the same is true for outlying tracts within city limits. Figure 7.1 indicates generally population changes from night to day as related to distance from the center of the city.

GENERALIZED DIAGRAM ILLUSTRATING
POPULATION CHANGES FROM NIGHT TO DAY
AS RELATED TO DISTANCE FROM CENTER OF CITY

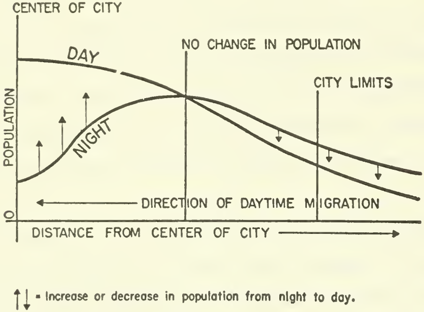


Figure 7.1

Communities may obtain estimates of day population, considered satisfactory for casualty estimation purposes, from their local street departments or from private sources. A suggested method, which may be used in preparing these estimates, is furnished at the end of this chapter.

In preparing day population estimates, figures should be developed for the city proper as well as for the suburban areas. The effects of a bomb do not stop at city limits. Estimates for the suburban areas need not be as accurate as for the city proper since the population densities in the suburbs are relatively low.

For an average American city the assumption can generally be made that approximately 33 percent of the residents of the suburbs come to the city in the daytime to work, to shop, to attend school, or for other purposes. This percentage varies somewhat according to how much of the entire residential area is included within the corporate limits, and according to the amount of employment and the number of stores and schools in outlying suburbs.

If the limits of a city pass through densely built-up areas, the city will have an abnormally large proportion of its resident population living outside the city limits. The percentage migration to the city will therefore be higher than 33. In contrast, another city which includes an abnormally large proportion of its resident population within the city limits and which has well developed industries and shopping and educational facilities in outlying suburbsmay be lower than 33.

Within the suburbs of any one city, the percentage of residents who migrate to the city in daytime varies from place to place. Ordinarily percentages are relatively high for inlying areas which have good transportation facilities, no industries, and meager shopping facilities. They are lower for areas where the opposite conditions prevail. For inlying suburbs the presence of industries appears to have little or no effect on the percentage of the residents that migrate to the city. This is because families in industrial suburbs commonly include a larger percentage of wage earners than do families in purely residential suburbs. The men are employed in heavy industries in the suburbs, whereas many of the women and young men go to the city to work in light industries.

In practice, moderate errors in estimating the percentage migration from small suburban areas will have no significant effect upon the accuracy of the resulting casualty estimates. This is due in part, to the relatively low population density of the suburbs as compared to the city proper, and in part to the fact that the bomb affects a large area and thereby tends to equalize plus and minus errors in estimating population for small suburban areas. Serious errors appear only when incorrect percentages are applied to relatively large areas.

The specific procedure to be used in estimating suburban daytime population by census tracts is as follows:

a. Determine the daytime population increase for a city proper by subtracting the figure for the total resident population within the city limits from the figure for the total day population for the same area.

b. On a map of census tracts for both the city and its suburbs, draw a tentative boundary that encloses those suburban areas which are known to contribute substantial numbers of people to the city (designated here as suburban A). This boundary should follow the census tract outlines and may conform in many instances to the corporate limits of towns.

c. Add up the resident population figures for the town and individual tracts composing suburban A.

d. Determine the percentage reduction within suburban A ncessary to provide the daytime population increase in the city proper. Example: Resident population of suburban A is 600,000. Daytime population increase for the city proper is 204,000. Average percentage assumed to be contributed by tracts of suburban A is 34.

e. If the percentage is more than 2 Or 3 percent above or below 33, determine whether this deviation may be due to inlying or outlying corporate limits or to employment and shopping facilities in outlying suburbs with resulting greater or less than average percentile migration.

f. If the deviation cannot be explained on the basis of these factors, alter the boundary of suburban A by tentatively adding or deleting areas until the percentage is approximately 33.

g. When this percentage has been determined, reduce the resident population figure for each census tract in suburban A by that percentage.

Manpower Data

"Civilian labor force" figures may be obtained in printed form from the Bureau of Census. The figures include all persons classified by the Bureau of Census as employed (all civilians 14 years old and over who were either "at work" or were "with a job but not at work")or unemployed. (persons 14 years old and over looking for work and persons waiting to be called back to a job from which they had been laid off or furloughed). Persons 14 years old and over not classified as members of the labor force by the Bureau of Census are considered "not in the labor force". Bureau of Census "civilian labor force" data represent resident and not daytime figures. Other sources for obtaining civilian labor force figures are: (a) U.S. Department of Labor (b) local departments of labor and (c) private sources.

Potential sources of manpower, such as: students and faculty located at institutions of higher education -- colleges and universities -- may be obtained from local (a) Boards of Education (b) Office of Civil Defense, Department of Defense (c) Health, Education and Welfare directories: The Education Directory and Higher Education Directory. Types of information to compile are:

a. Name, address and geographic location of facilities
b. Number of all students
c. Number of medical students
d. Number of dental students
e. Number of engineering students
f. Number of graduate students
g. Number of faculty

Types of health manpower considered essential for postattack operations purposes are:

a. medical doctors
b. doctors of osteopathy
c. dentists
d. veterinarians
e. nurses
f. pharmacists
g. sanitary engineers
h. sanitarians

Sources of data for health manpower may be obtained from:

a. American Medical Association
b. American Osteopath Association
c. American Dental Association
d. American Veterinary Medicine Association
e. American Nurses Association
f. American Pharmaceutical Association and/or National Association of Boards of Pharmacy
g. National associations of sanitarians
i. Health, Education and Welfare, Public Health Methods of Public Health Service
j. Local health organizations.
k. Office of Civil Defense, Department of Defense

Distribution of Population in Graphic Form

Two graphic techniques, each of which is desirable under certain conditions, have been developed for depicting the distribution of population. One technique employs a single unequal value dot; the alternate technique employs multiple equal value dots.

Point Location Method

The single unequal value dot or point location method is based on the assumption that the entire population, encompassed within a geographic area, such as a census tract or Census County Division, is concentrated at the central point of the area. This method is especially well adapted for depicting the distribution of the population on small scale schematics showing either numerous census tracts or Census County Divisions. For cities, the procedure is as follows:

a. Obtain a schematic depicting the boundaries of census tracts.

b. Visually inspect each tract on the schematic to determine its center and, at the location selected, mark a dot on the schematic.

Figure 7.1 illustrates the application of the procedure for a hypothetical city. This type of visual may be used in conjunction with a listing of the tracts showing the population data for estimation purposes. Table 7.1 illustrates the type of form local civil defense organizations can design and use.

Figure 7.1 depicts the boundaries of each tract and identifies each by tract number only. It does not furnish the population data. Therefore, to eliminate reference to a table of population figures, the value of each dot can be indicated directly onto a schematic. If this is done, the tract number need not appear on the visual. Figure 7.3 illustrates this procedure.

Illustration
of
Distribution of Population - 1960
for a Hypothetical City

Point Location Method
(Unequal Value Dot)

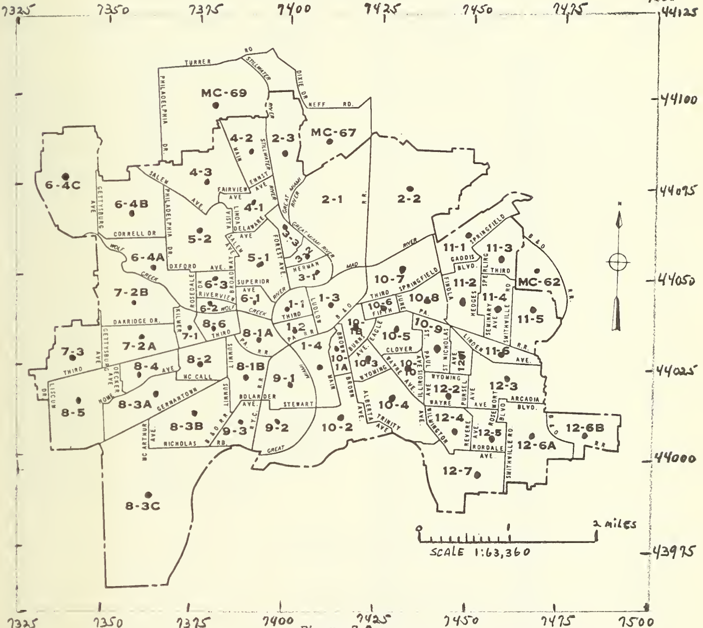


Figure 7.2

Note: The boundary depicts the UTM tick marks . The hypothetical city is located in Zone 16.

Table 7.1

Hypothetical City

1960 Resident Population by Tracts

Tract Number	Population	Casualty Zone I	Casualty Zone M	Casualty Zone O
1-1	2158			
1-2	2522			
1-3	728			
1-4	1248			
2-1	5274			
2-2	8883			
2-3	1620			
3-1	2605			
3-2	1780			
3-3	3188			
4-1	5318			
4-2	5865			
4-3	8603			
5-1	8308			
5-2	8157			
6-1	3297			
6-2	902			
6-3	4017			
6-4a	4181			
6-4b	6981			
6-4c	6462			
7-1	2765			
7-2a	5927			
7-2b	6977			
7-3	4608			
8-1a	5173			
8-1b	5100			
8-2	5078			
8-3a	5609			
8-3b	7026			
8-3c	4632			
8-4	2462			
8-5	4245			
8-6	2615			
9-1	5433			
9-2	1326			
9-3	2218			
10-1a	3796			
10-1b	3131			
10-2	3675			
10-3	4189			
10-4	3161			
10-5	6394			
10-6	1511			
10-7	2461			
10-8	5395			
10-9	4105			
10-10	4694			
11-1	900			
11-2	6564			
11-3	2155			
11-4	3683			
11-5	4628			
11-6	1238			
12-1	2727			
12-2	4652			
12-3	6582			
12-4	2331			
12-5	3004			
12-6a	6818			
12-6b	4630			
12-7	6617			
MC-62	4239			
MC-67	3982			
MC-69	5263			
Total	275,816			

Legend: I - inner ; M-Middle; O-Outer

Instruction for Estimation Use: Insert in appropriate slot the population figure for tract involved.

Illustration
of
Distribution of Population (hundreds) - 1960
for a Hypothetical City

Point Location Method

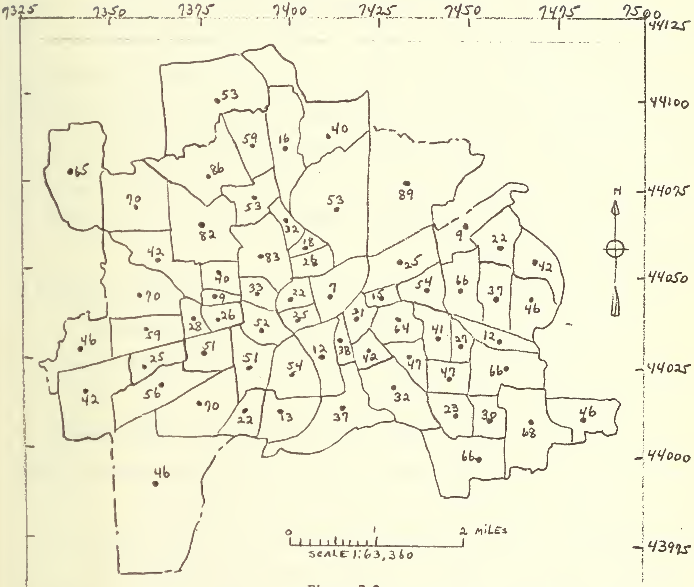


Figure 7.3

Note: The boundary depicts the UTM tick marks. The hypothetical city is located in zone 16.

Census tracts are irregular configurations of varying areal size. The use of census tracts is recommended for manually depicting the locations of the population because new types of areal configurations need not be devised. It should be recognized, however, the locations of the population can be depicted by use of areas other than census tracts. Circles, rectangles, and squares, for example, may be designed for depicting the locations of the population provided the population data for the areas designed are available. OCD has developed procedures whereby an electronic computer can print on an 8½ by 11 inch sheet of paper, depicting a grid consisting of 2.5 by 2.5 kilometer squares -- standard shaped areas and sizes -- the number of individuals located within each square. The following furnishes a general explanation of the procedure:

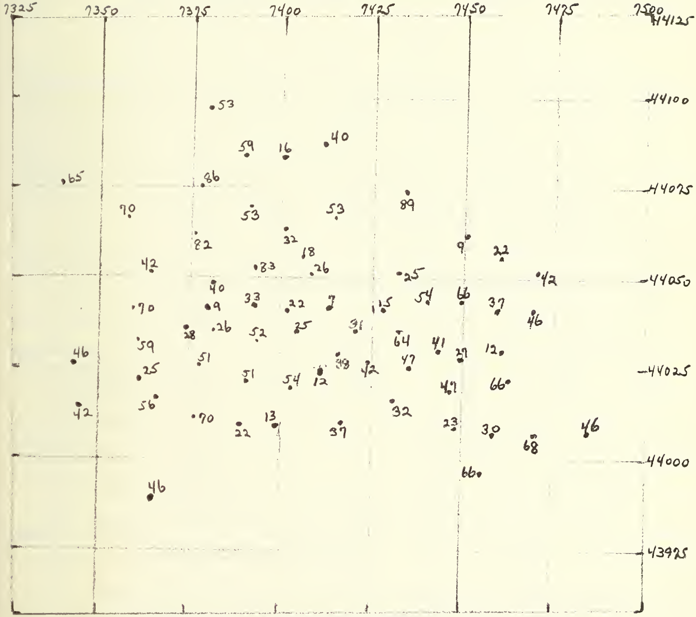
a. For each populated area of 50,000 or more, the computer aggregates all the "points," as selected and identified for the National Location Code, located within each 2.5 and 2.5 kilometer square encompassing the area involved.

b. The computer adds the values associated with each "point" located within a 2.5 by 2.5 kilometer square and, within each square, prints the sum of the values of the points located therein.

The development of a lattice preplot of population is visually depicted in figures 7.4 and 7.5. Figure 7.3 depicts a grid superimposed on the hypothetical city used for illustration purposes. Each square is 2.5 by 2.5 kilometers. Within each square are depicted the "point locations" (derived from the census tract shematic) and their associated population values. Figure 7.5 depicts for each 2.5 by 2.5 kilometer square the total population, or the sum of the values associated with each point, located in a square as depicted in figure 7.4.

Illustration of a Development of a Lattice Preplot of Resident Population - 1960 (in hundreds) for a Hypothetical City

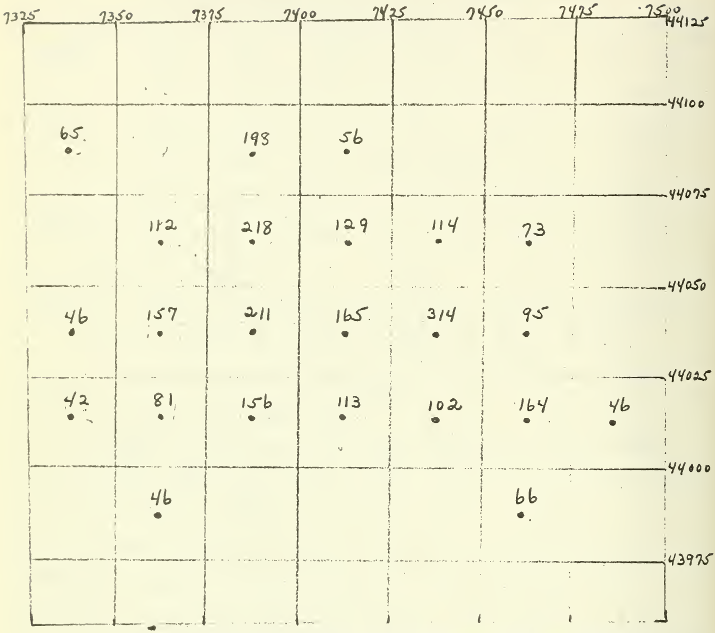
Graphic Distribution of Centers of Tracts Located Within Each
2.5 by 2.5 Kilometer Square



Note: The boundary depicts the UTM tick marks. The hypothetical city is located in zone 16.

Figure 7.4

Illustration
of a
Lattice Preplot of Resident Population-1960 (hundreds)
for a Hypothetical City



Note: Points depicted for illustration purposes only. Computer printouts will depict population data only. The hypothetical city is located in zone 16.

Figure 7.5

Equal-Value-Dot Method

An alternate method of depicting the distribution of population is the plotting of population on a census tract schematic or map by means of equal value dots. The procedure for use in conjunction with a census tract schematic is as follows:

Within the census tracts for the area desired, place dots, each of which represents the same number of people (500, 1,000 or more), to indicate the distribution of either daytime or resident population. If possible, place dots equally spaced apart. Census tract schematics do not show unpopulated areas such as parks. Consequently, it is difficult to take such areas into consideration when plotting the dots. The most suitable value and size for the dot may be determined by plotting the data tentatively on a scrap of tracing paper over the area of densest population. If the dots merge so that they cannot be counted, a smaller point or the value of each dot should be increased. (An illustration of the application of the equal-value-dot method is presented in figure 7.6.)

The procedure for use in conjunction with a large scale map (scale 1:24,000) is as follows:

a. First - Delineate the boundaries of the census tracts on the map.

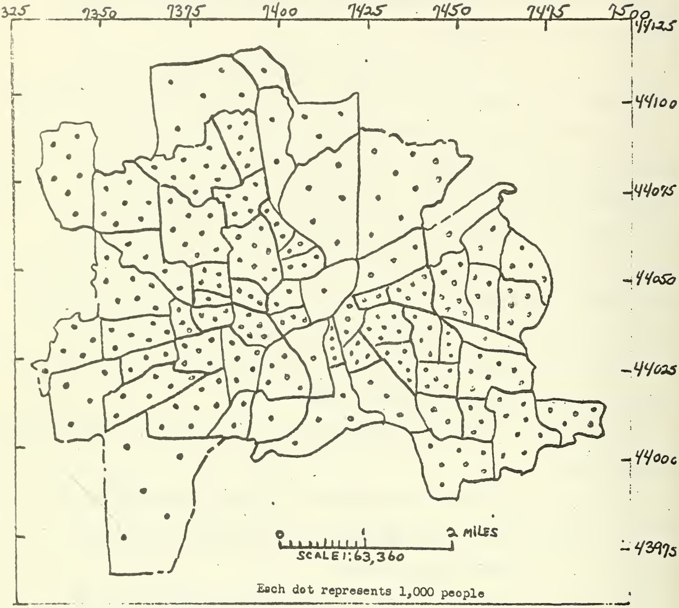
b. Second - Outline unpopulated areas such as parks, rail yards, water bodies and so on.

c. Third - Determine the most suitable value and size for the dot to be used for plotting purposes.

d. Fourth - Place dots as accurately as practicable in the remaining areas according to the known distribution of the population.

Illustration
of
Distribution of Resident Population - 1960

Equal-Value-Dot Method



Note: The boundary depicts the UTM tick marks. The hypothetical city is located in zone 16.

Figure 7.6

The procedure for use in conjunction with a 1:250,000 scale urbanized area boundary outline map is as follows:

a. Obtain total population figure for the urbanized area under consideration. U.S. Department of Commerce, Bureau of Census release PC(S1)-5 "Population or Urbanized Areas: 1960 and 1950" dated June 14, 1962, furnishes resident population figures.

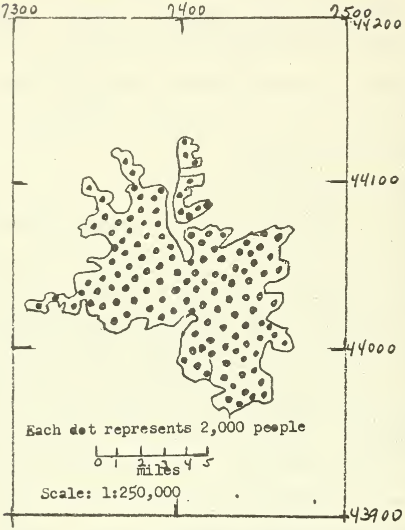
b. Determine the most suitable value and size for the dot to be used for plotting purposes.

c. Plot dots equally spaced apart.

An illustration of the application of the equal-value-dot method used in conjunction with a 1:250,000 scale map is presented in figure 7.9.

The equal-value-dot method, used in conjunction with a census tract schematic, furnishes a visual depicting the population distributed within a tract; the technique, used in conjunction with a 1:250,000 scale map, furnishes a visual depicting the population distributed equally throughout the urbanized area. The scale of the map being used influences the amount of detail that can be depicted. Use of small scale maps prevent depiction of detail such as showing the population distributed within a tract; however, their use facilitate obtaining rapidly estimates of the magnitude of survivors remaining and casualties sustained.

Illustration
of
Distribution of Resident Population-1960
Equal-Value-Dot Method



Note: The boundary depicts the UTM tick marks. The hypothetical city is located in zone 16.

Figure 7.7

Visual inspection of figures 7.2, 7.3, 7.5, 7.6 and 7.7 reveals various methods may be employed by a local civil defense organization for depicting the distribution of population. The point location technique does not depict the concentrations of the population within a city. The equal-value-dot method furnishes at a glance where the people are in a city, especially when a 1:24,000 scale map is sued and, therefore, is useful for revealing the probable distribution of casualties within a city as well as for "fine-grain" analytical studies relating the shelter needs. Both the point location and equal-value-dot techniques, however, are suitable for estimating the survivors remaining and/or casualties from direct effects only. Each civil defense organization should analyze the procedures and select the method most suitable for its needs. The procedures presented are simple and comparatively easy to apply especially by volunteers and other relatively inexperienced people under minimum supervision.

The point location and/or equal-value-dot techniques can also be used for depicting the following:

a. Manpower - labor force

b. Potential sources of manpower:

   (1) students

   (2) medical students

   (3) dental students

   (4) engineering students

   (5) graduate students

   (6) faculty

c. Health manpower

    (1) medical doctors

    (2) doctors of osteopathy

    (3) dentists

    (4) veterinarians

    (5) nurses

    (6) pharmacists

    (7) sanitary engineers

    (8) sanitarians

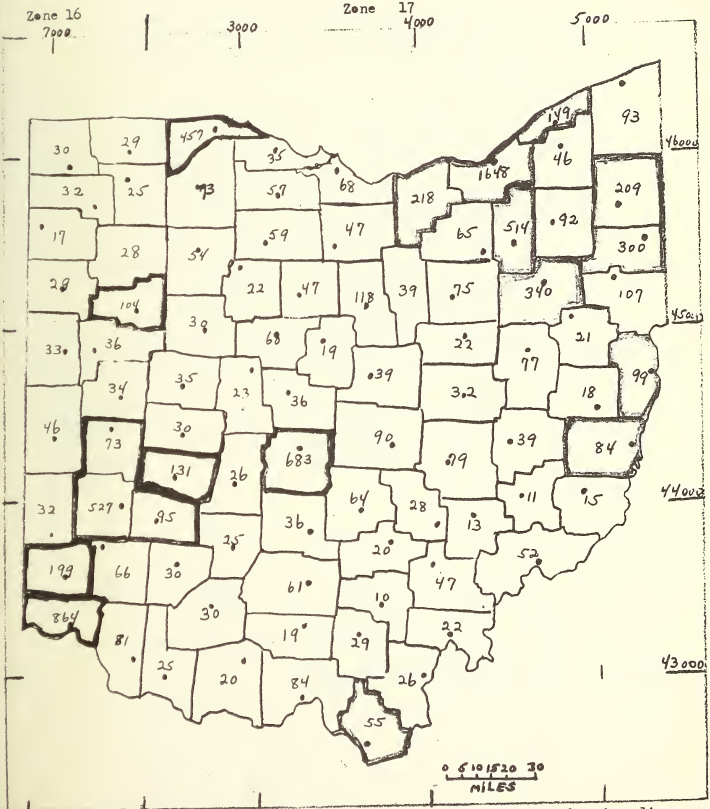
The distribution of the population for a State for use in estimating population "at risk" from fallout and affected by fallout may be depicted by use of the "point location" or equal-value-dot techniques or variations of these techniques. A very simplified procedure of the point location technique is as follows:

a. Obtain a schematic depicting the boundaries of the counties.
   (U. S. Department of Commerce, Bureau of Census publication PC(1) series "Population-1960, General Social and Economic Characteristics " contains a $9x11\frac{1}{2}$ inch State map depicting the boundaries of counties.)

b. Select for each county the location of the city with the largest number of people to serve as the "point location".

c. Assign to each point selected the total population of the county involved under the assumption all the people in the county are located at the point selected. Figure 7.8 illustrates the application of the procedure. The illustration depicts the UTM information in the form of border tick marks and the population located within each county. The name of each county, although not shown, may be depicted if desired.

Illustration
of
Distribution of Resident Population-1960 (thousands)
for a Hypothetical State



Note: The UTM tick marks shown on the border of the schematic. Heavy boundary lines delineate the Standard Metropolitan Statistical Areas.

Figure 7.8

A more sophisticated procedure involving extensive mathematical computations is as follows:

a. Obtain a schematic depicting the boundaries of the counties.

b. Select two or more "point locations" for each county. In general, the 4 or 5 largest cities can be selected to represent the "point locations".

c. Assign to each "point location" selected the population value to be associated with the point. A method of assigning the population values to the points selected within a county is as follows:

    (1) Add the total populations of the cities selected.

    (2) For the cities selected, determine the distribution of the population in terms of percents.

    (3) Apportion the total population of the county to each city selected in accordance with the percents developed.

Example:

City	City Population (thousands)	Percent	Proportion of county population assigned (thousands)
A	27	27	54
B	23	23	46
C	50	50	99
Total	100	100	199

An illustration of the above procedure has not been developed and, therefore, is not included in this document.

When employing the equal-value-dot technique the procedure is as follows:

a. Obtain a schematic depicting the boundaries of counties.

b. Obtain the population figure for each county.

c. Determine the most suitable value and size for the dot to be used for plotting purposes. For some small sized counties containing large numbers of people space limitations may necessitate the use of a symbol other than a dot, such as an "x" having a larger value.

d. Plot the dots and other symbols equally spaced apart.

Figure 7.8 illustrates the application of the above procedure. State civil defense organizations should analyze each of the procedures described above and select the procedure most suitable for its needs. Where alternate improved methods are developed, they should be employed.

State civil defense organizations may depict manpower data in the same manner as illustrated in figures 7.8 and 7.9.

Illustration
of
Distribution of Resident Population-1960 (thousands)
for a Hypothetical State

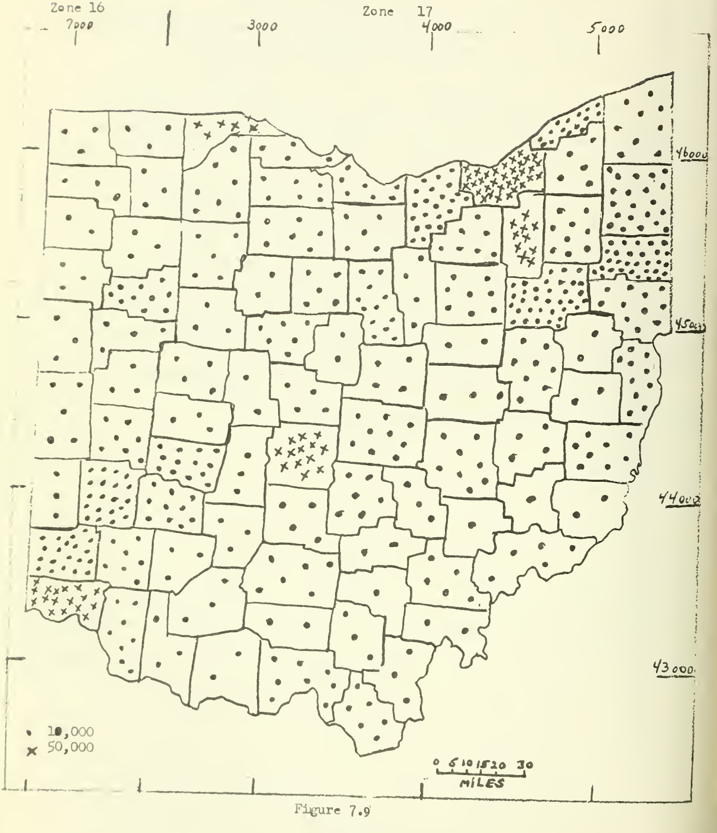


Figure 7.9

Weapons Data

Essential for estimation purposes are basic weapons effects data for the blast area only and for the fallout area only. For the blast area only it is necessary to know the radii of the casualty zones for both air and surface bursts and the survivor and casualty multipliers to use for the appropriate casualty zones. For the fallout area only, it is necessary to know the extent of the fallout contours and the survivor and casualty multipliers to apply for the population located within each of the fallout contours.

Blast Area Only (Direct Effects)

Casualty Zone Radii Data

The following table furnishes the radii(in miles) for the casualty zones for weapon yields 1-3-5-10-20 megatons, for air and surface bursts, for use in conjunction with percentage multipliers in developing estimates of survivors and casualties with the blast area only.

Casualty Zone Radii for Air and Surface Bursts

(Direct Effects Only)

Casualty Radii

Weapon size (Megatons)	Casualty Zone	Air Burst Radii (miles.	Surface Burst Radii (miles)
1 MT	Inner	0.0 - 2.2	0.0 - 1.7
	Middle	2.2 - 5.9	1.7 - 4.4
	Outer	5.9 - 11.4	4.4 - 8.6
3 MT	Inner	0.0 - 3.1	0.0 - 2.3
	Middle	3.1 - 8.4	2.3 - 6.3
	Outer	8.4 - 16.2	6.3 - 12.2

(Derivation : 1.44 times figures for 1 MT)

5 MT	Inner	0.0 - 3.8	0.0 - 2.9
	Middle	3.8 - 10.1	2.9 - 7.6
	Outer	10.1 - 19.5	7.6 - 14.6

(Derivation : 1.71 times figures for a 1 MT

10 MT	Inner	0.0 - 4.7	0.0 - 3.5
	Middle	4.7 - 12.7	3.5 - 9.5
	Outer	12.7 - 24.5	9.5 - 18.4

(Derivation: 2.15 times figures for a 1 MT)

20 MT	Inner	0.0 - 6.0	0.0 - 4.5
	Middle	6.0 - 16.0	4.5 - 12.0
	Outer	16.0 - 30.9	12.0 - 23.2

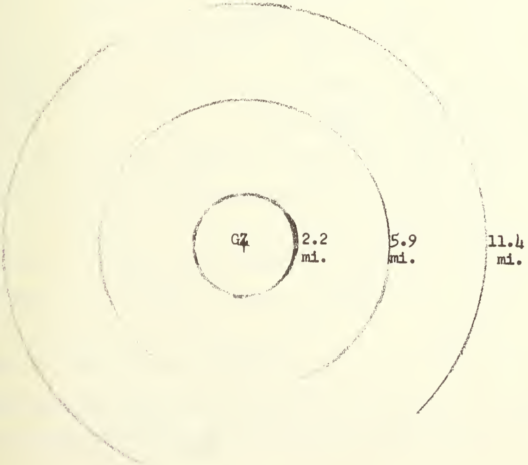
(Derivation: 2.71 times figures for a 1 MT)

If casualty zone radii are desired for weapon yields not listed in table above, the information may be developed by use of the cube root figures shown in column b, page D-23, "Appendix D - Nuclear Weapons Information". Example: if radii are desired for a 2-MT, multiply the radii shown in table above for a 1-MT by 1.26 (cube root of 2).

Casualty Templates

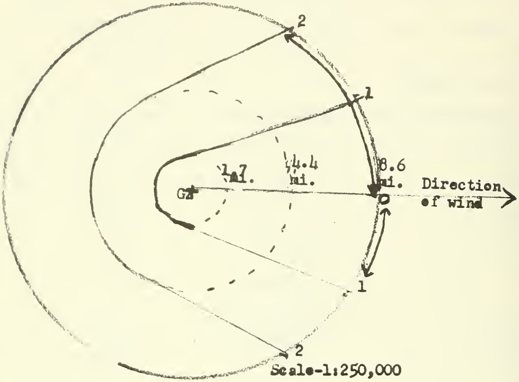
The casualty zone radii are used as a basis for developing casualty templates. The following illustrations depict the application of the casualty zone radii for an air and surface burst for a single detonation.

Illustration
of
Casualty Template
for
1-MT Air Burst



Scale: 1:250,000

Illustration
of
Casualty Template
for
1-MT Surface Burst



The following furnishesthe procedure to use for constructing a casualty template for a surface burst:

a. Distance from 0 to 1 on the outer circle - same as the distance from GZ to the perimeter of the middle zone (in the illustration - 4.4 miles)

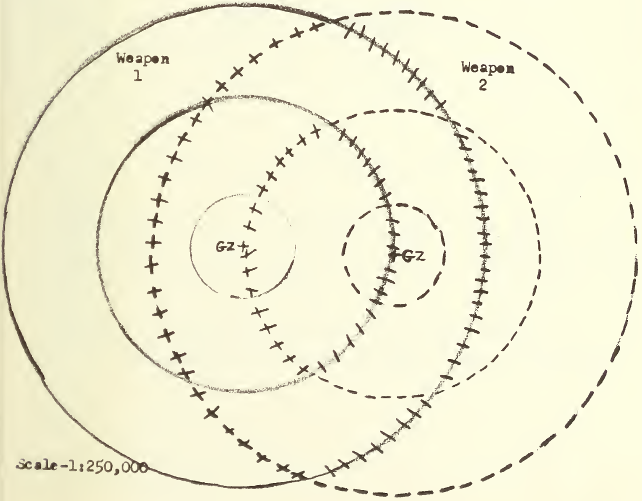
b. Distance from 0 to 2 on the outer circle - same as the distance from GZ to the perimeter of the outer zone (in the illustration - 8.6 miles)

For purposes of estimating the residual radiation effect on people located within the blast area, the radii of the middle and outer casualty zones have been arbitrarily selected for constructing the contour lines.

The dotted lines are to illustrate the extent of the inner and middle zones only; they should not be delineated when constructing a casualty template for a surface burst.

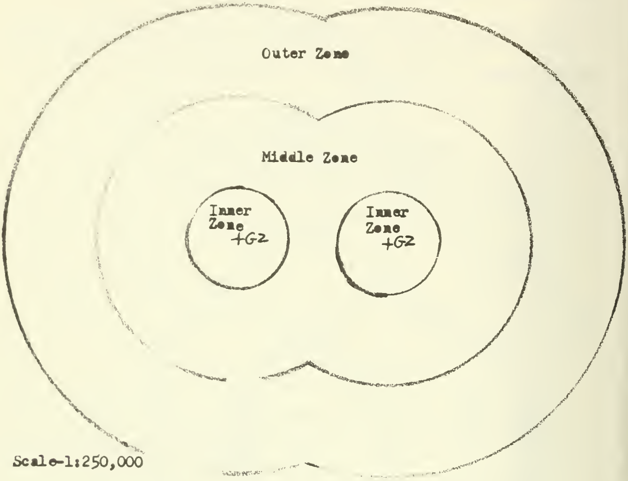
The following depicts how a casualty template involving multiple detonations may be constructed:

Illustration
of
Development of Casualty Template
for
Two Weapons - each 1-MT Air Bursts



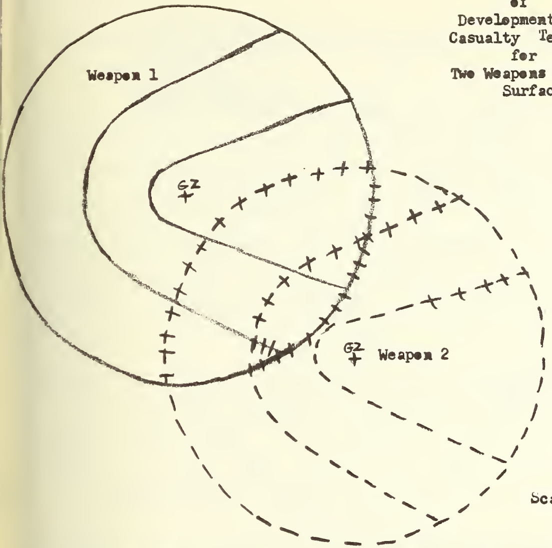
Eliminating the crossed portions in the above illustration furnishes the casualty template as depicted in the following illustration.

Illustration
of
Casualty Template
for
Two Weapons- each 1-MT Air Burst



The following depicts how a casualty template for multiple detonations involving surface bursts may be constructed.

Illustration
of
Development of
Casualty Template
for
Two Weapons - each 1-MT
Surface Burst



Scale-1:250,000

Eliminating the crossed and hatched portions in the above illustration furnishes the casualty template as depicted in the following illustration:

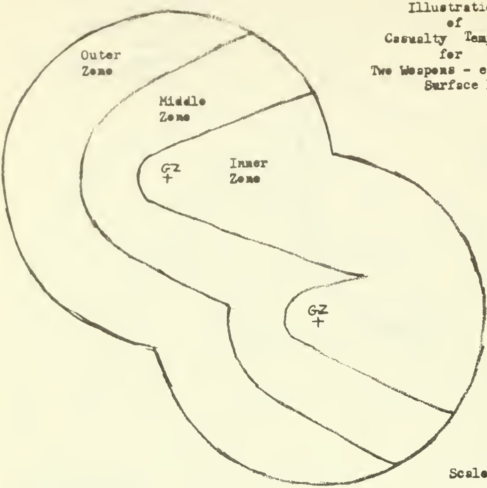


Illustration
of
Casualty Template
for
Two Weapons - each 1MT
Surface Burst

Scale-1:250,000

When constructing casualty templates for multiple detonations, employ the boundaries of the dominant casualty zones for all overlapping areas.

The above illustrated templates are also applicable for estimating the effects of a nuclear detonation on manpower as well as personnel located within specified facilities such as hospitals, schools and so forth.

Survivor and Casualty Percentage Multipliers - Direct Effects

Without Warning

Without warning refers to the situation where a civil defense organization does not have sufficient time to instruct the population to take evasive action, such as: proceed to a fallout shelter or seek best protection available. Sufficient time, as used herein, implies less than 15 minutes of warning. Estimates of survivors and casualties within the blast (direct effects) area from the detonation of a nuclear weapon may be developed by use of the following percentages:

Survivors

Casualty zone	Air burst			Surface burst		
	Total	Not hurt	Hurt	Total	Not hurt	Hurt
Inner	13	5	8	0	0	0
Middle	69	36	33	69	36	33
Outer	98	81	17	98	81	17

Casualties

Casualty zone	Total	Deaths	Hurt	Total	Deaths	Hurt
Inner	95	87	8	100	100	0
Middle	64	31	33	64	31	33
Outer	19	2	17	19	2	17

With Warning

With warning refers to the situation where a civil defense organization warns and instructs the population to take evasive action. Instructions might be to proceed to the nearest fallout shelter, seek best protection available or other type of action. In terms of time, it implies more than 15 minutesof warning. Estimates of survivors and casualties within the blast area may be developed by use of the following percentages:

Survivors

Casualty zone	Air burst			Surface burst		
	Total	Not hurt	Hurt	Total	Not hurt	Hurt
Inner	30	15	15	0	0	0
Middle	90	65	25	90	65	25
Outer	99	98	1	99	98	1

Casualties

Casualty zone	Total	Deaths	Hurt	Total	Deaths	Hurt
Inner	85	70	15	100	100	0
Middle	35	10	25	35	10	25
Outer	2	1	1	2	1	1

The above average percentages are for use with all weapon sizes; however, the limits of each of the three casualty zones will vary with the size of the weapon.

Application of the survivor average percentages will enable civil defense personnel to develop survivor estimates for use as a basis for developing preliminary estimates of requirements for food, water, housing and other types of resources; casualty estimates may be used as a basis for developing preliminary estimates for medical requirements.

The following definitions are furnished for clarification:

Deaths: Fatalities resulting from injuries sustained from the detonation of a nuclear weapon; Individuals who die immediately after the detonation as well as those who die within 60 days.

Hurt : Individuals sustaining an injury not resulting in death.

Casualties: Fatalities and injured population.

Survivors: The injured and uninjured population.

Time-phasing of deaths, if required for computing medical requirements, may be developed by use of the following percentage multipliers:

Time	Percent of Total Deaths	Percent of Total Deaths Fatally Injured
Day 1	67 (1/3 die immediately after detonation; 1/3 die by end of 24 hours)	33
Day 7	83	17
Day 14	91	9
Day 60	100	0

Estimates of the types of injuries among the casualties who survive a nuclear detonation, i.e. excluding those who die immediately after a detonation, may be developed by use of the following percentages:

Distribution of Types of Injury Among Survivors

Injury	Percent of Survivors
Blast (mechanical)	70
Burns (flash and flame).............	65
Nuclear radiation (initial)..........	30 (air burst only) (For a surface burst the figure will exceed 30 percent)

Since many of the individuals will suffer multiple injuries, it should be observed the totals add up to more than 100 percent.

Surviver and Casualty Estimation Forms - Direct Effects Only

To facilitate the computation of casualties and survivors, two basic forms have been designed. The Casualty Estimation Form, for estimating the casualties which will occur within the blast area only, will furnish the following information:

a. The magnitude as well as the distribution of casualties by type, i.e. deaths and injured as of D plus 60 days.

b. The anticipated deaths and fatally injured by time period, i.e. D plus 1 day; B plus 7 days; D plus 14 days and D plus 60 days. Fatally injured, as used herein, refers to individuals who sustain injuries which result in death by the end of 60 days.

Two forms have been designed for casualty estimation purposes: (1) for without warning and (2) with warning. Although the casualty percentage multipliers for without warning and with warning differ, it should be noted the percentage multipliers for the anticipated deaths and anticipated fatally injured for both without warning and with warning remain the same.

Estimates of survivors within the blast areamay be computed by use of the Surviver Estimation Form. The fatally injured do not survive and, consequently, have not been included in the form. Survivors represent individuals who are not hurt as well as those who sustain injuries but recover. Survivors also include all population located outside the blast and fallout areas.

Casualty Estimation Form

Direct Effects Only
Without Warning

OCD Region : ____________

State : ____________

SMSA : ____________

Population : ____________

Weapon Size : ____________

Type of Burst: ____________

Ground Zero : ____________

Time and Day of Detonation : ____________

Casualty Radii

Zone	Radii
Inner :	
Middle :	
Outer :	

Preattack Population

Det Value ____________

Prediction of Casualties at end of 60 days

Zone	Number of dets	Estimated Population	Deaths		Hurt		Total
			Percent	Number	Percent	Number	Casualties
Inner			S-100 A-67		S-0 A-8		
Middle			31		33		
Outer			2		17		
Total			╳		╳		

Anticipated Deaths by Time

Day	Deaths as of End of D plus 60						
	Inner Zone		Middle Zone		Outer Zone		Total Anticipated Deaths
	%	Number	%	Number	%	Number	Number
1	100		67		67		
7	100		83		83		
14	100		91		91		
60	100		100		100		

	Anticipated Fatally Injured by Time						Total
1	0		33		33		
7	0		17		17		
14	0		9		9		
60	0		0		0		

Casualty Estimation Form

Direct Effects Only

With Warning

OCD Region : __________
State : __________
SMSA : __________
Population : __________

Weapon Size : __________
Type of Burst : __________
Ground Zero : __________
Time and Day of Detonation : __________

Casualty Radii

Zone	Radii
Inner :	
Middle :	
Outer :	

Preattack Population

Det Value __________

Prediction of Casualties at end of 60 days

Zone	Number of dets	Estimated Population	Deaths		Hurt		Total Casualties
			Percent	Number	Percent	Number	
Inner			S-100 A-70		S-0 A-15		
Middle			10		25		
Outer			1		1		
Total							

Anticipated Deaths by Time

Day	Deaths as of End of D plus 60						
	Inner Zone		Middle Zone		Outer Zone		Total Anticipated Deaths Number
	%	Number	%	Number	%	Number	
1	100		67		67		
7	100		83		83		
14	100		91		91		
60	100		100		100		

	Anticipated Fatally Injured by Time						Total
1	0		33		33		
7	0		17		17		
14	0		9		9		
60	0		0		0		

Survivor Estimation Form

Direct Effects Only
Without Warning

OCD Region :
State :
SMSA :
Population :

Weapon Size :
Type of Burst :
Ground Zero :
Time and Day of Detonation :

Casualty Radii

Zone	Radii
Inner :	
Middle :	
Outer :	

Preattack Population

Dot Value

Prediction of Survivors at end of 60 days

Zone	Number of dots	Estimated Population	Not Hurt		Hurt		Total Survivors
			Percent	Number	Percent	Number	
Inner			S - 0 A - 5		S- 0 A-8		
Middle			36		33		
Outer			81		17		
Total			╳		╳		

With Warning

Preattack Population

Dot Value

Prediction of Survivors at end of 60 days

Zone	Number of dots	Estimated Population	Not Hurt		Hurt		Total Survivors
			Percent	Number	Percent	Number	
Inner			S - 0 A -15		S- 0 A-15		
Middle			65		25		
Outer			98		1		
Total			╳		╳		

Remarks: The survivor figure does not include the fatally injured who eventually die within 60 days. The fatally injured by time period, if desired, may be obtained from the Casualty Estimation Form.

Estimating Casualties From Indirect Effects (Fallout Only)

In a surface burst, the extent and nature of the fallout can range between wide extremes. Factors affecting the shape of the fallout pattern are:

(1) Yield and design of the weapon

(2) The height of burst

(3) Meteorological conditions

(4) Nature of the terrain

The total amount of radioactivity that ppears in the fallout area depends on the extent to which the fireball comes in contract with the ground, and is greater when the height of burst approaches zero and more of the fireball descends within the earth. From a contact surface burst, about 50 to 80 percent of the total residual radioactivity will be deposited on the ground within a few hundred miles of the burst.

Meteorological conditions and other factors influence the size, shape, and location of the fallout pattern on the ground. The wind structure between the ground and the tope of the nuclear cloud is the most important factor.

The size, shape, location, and intensities of the contours within the pattern are dependent on the size distribution of particles and their activity in the cloud. This size distribution of the particles is affected to a certain degree by the nature of the terrain over which the weapon is detonated.

As a general rule, the fallout will form an irregular elongated pattern of contamination. This is called the downwind pattern. Its shape and dimensions will be determined by the speeds, directions and shear of all winds between the ground and top of the nuclear cloud. For illustration purposes only, an idealized, theoretical downwind pattern of contamination, showing several dose rate contours, is depicted schematically in figure 7.10. The contour lines shown have been smootheed; however, it should be remembered this has been done purely for illustrative purposes. In an actual situation, the contour lines will be jagged and within the fallout pattern will be areas which will contain dose rates higher than the surroundings, call "hot spots".

At any given location downwind, some time will elapse before fallout arrives. The time of arrival depends on:

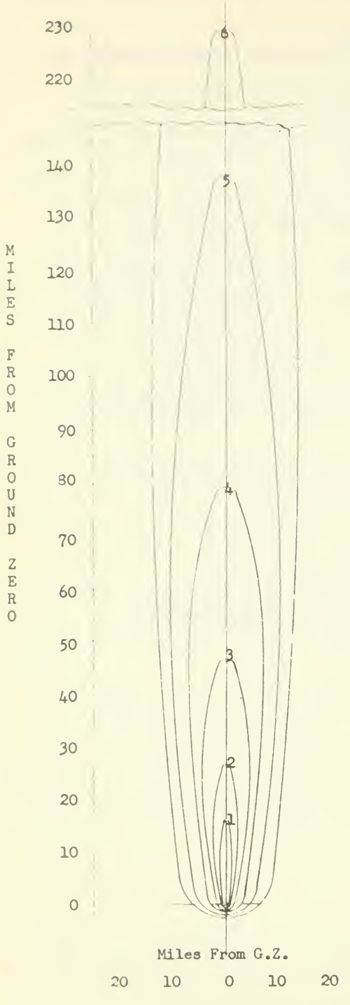
(1) Distance from ground zero

(2) Size and altitude of the cloud

(3) Time required for particles to fall to the ground

(4) Speed of the effective wind

Schematic Illustration
of a
Fallout Downwind Pattern



Dose Rate Contours
1-megaton surface burst
(15 mph effective wind).
50% Fission - 50% Fusion

Remarks:
1 hour reference dose rates

Contour	Dose rate
1	3000r/hr
2	1000r/hr
3	300r/hr
4	100r/hr
5	30r/hr
6	10r/h4

Figure 7.10

The dose rate contours and dose rates within the fallout pattern at each successive hour after H plus 1 are constantly changing. After fallout is complete at a given location, the dose rates decrease with time. An approximate rule is as follows: for every seven-fold increase in time after the explosion, the activity decreases by a factor of ten. For example, if the radiation intensity at a location 1 hour after the explosion is taken as a reference time, then at 7 hours after the explosion, the intensity at that location will have decreased to one-tenth; at 7x7=49 hours (or roughly 2 days) it will be one-hundredth; at 7x7x7=343 hours (or roughly 2 weeks) the activity will be one-thousandth of that at 1 hour after the burst. This rule is roughly applicable for about 100 days, after which the radiation intensity decreases more rapidly than indicated by the above rule.

Table 7.2 furnishes the dose rates at specific hours for contours 1-2-3-4-5 and 6.

Table 7.3 furnishes the total dose between specified time periods.

Table 7.4 furnishes the total dose from time of arrival of fallout thru H plus 24 hours.

In general, at any given location at a distance from a surface burst, some time will elapse before the fallout arrives. For the conditions assumed in the example depicted (see figure 7.10), the fallout comprising contour 1 is down by H plus 2 hours; contour 2 by H plus 3 hours; contour 3 by H plus 5 hours and contour 4 by H plus 8 hours.

Dose Rates at Specified Hours
Outside

Time From Detonation	Overall Dose Rate Factor t-1.2	Contour 1 r/hr	Contour 2 r/hr	Contour 3 r/hr	Contour 4 r/hr	Contour 5 r/hr	Contour 6 r/hr
H+1	1.000	3000.0	1000.0	300.0	100.0	30.0	10.0
H+2	.440	1320.0	440.0	132.0	44.0	13.2	4.4
H+3	.270	810.0	270.0	81.0	27.0	8.1	2.7
H+4	.200	600.0	200.0	60.0	20.0	6.0	2.0
H+5	.150	450.0	150.0	45.0	15.0	4.5	1.5
H+6	.120	360.0	120.0	36.0	12.0	3.6	1.2
H+7	.097	291.0	97.0	29.1	9.7	2.91	0.97
H+8	.085	255.0	85.0	25.5	8.5	2.5	0.85
H+9	.072	216.0	72.0	21.6	7.2	2.16	0.72
H+10	.063	189.0	63.0	18.9	6.3	1.89	0.63
H+11	.057	171.0	57.0	17.1	5.7	1.71	0.57
H+12	.051	153.0	51.0	15.3	5.1	1.53	0.51
H+13	.046	138.0	46.0	13.8	4.6	1.38	0.46
H+14	.042	126.0	42.0	12.6	4.2	1.26	0.42
H+15	.039	117.0	39.0	11.7	3.9	1.17	0.39
H+16	.036	108.0	36.0	10.8	3.6	1.08	0.36
H+17	.033	99.0	33.0	9.9	3.3	0.99	0.33
H+18	.031	93.0	31.0	9.3	3.1	0.93	0.31
H+19	.030	90.0	30.0	9.0	3.0	0.90	0.30
H+20	.027	81.0	27.0	8.1	2.7	0.81	0.27
H+21	.026	78.0	26.0	7.8	2.6	0.78	0.26
H+22	.025	75.0	25.0	7.5	2.5	0.75	0.25
H+23	.023	69.0	23.0	6.9	2.3	0.69	0.23
H+24	.022	66.0	22.0	6.6	2.2	0.66	0.22
H+48	.0095	28.5	9.5	2.85	0.95	0.285	0.095
H+72	.0060	18.0	6.0	1.80	0.60	0.180	0.060
H+96	.0042	12.6	4.2	1.26	0.42	0.260	0.042
H+120	.0032	9.6	3.2	0.96	0.32	0.096	0.032
H+144	.0026	7.8	2.6	0.78	0.26	0.078	0.026
H+168	.0022	6.6	2.2	0.66	0.22	0.066	0.022
H+2 Wks	.0009	2.7	0.9	0.27	0.09	0.027	0.009
H+1 Mo	.0004	1.2	0.4	0.12	0.04	0.012	0.004

For dose rates within structures, apply the following:

1. Frame house:
   First floor - 1/2 of outside
   Basement - 1/10 of outside
   Corner of Basement - 1/20 of outside
2. Multistory reinforced concrete structure:
   Lower floors (away from windows) - 1/10 of outside
   Basement (surrounded by earth) 1/1000 of outside

3. Shelter below grade with 3 feet of earth - 1/1000 of outside

To obtain the dose rate for a specific contour at a specified hour, multiply the overall dose rate factor by the dose rate at H+1. Example: Find the dose rate for contour 2 at H+4 hours. Solution: Overall dose rate factor for H+4 hours is .200x1000r/hr at H+1 (contour 2) = 200r/hr at H+4 (answer).

Table 7.2

Total Dose,

Between Time Periods Indicated

Outside

Time Periods	Dose Factors For Time Periods	CONTOUR					
		1	2	3	4	5	6
		3000r/hr-H+1	1000r/hr-H+1	3004/h4-H+1	100r/hr-H+1	30r/hr-H+1	10r/hr-H+1
		r	r	r	r	r	r
H+1-H+2	0.600	1800	600	180.0	60.0	18.00	6.00
H+2-H+3	0.400	1200	400	120.0	40.0	12.00	4.00
H+3-H+4	0.200	600	200	60.0	20.0	6.00	2.00
H+4-H+5	0.170	510	170	51.0	17.0	5.10	1.70
H+5-H+6	0.150	450	150	45.0	15.0	4.50	1.50
H+6-H+7	0.100	300	100	30.0	10.0	3.00	1.00
H+7-H+8	0.085	255	85	25.5	8.5	2.55	0.85
H+8-H+9	0.072	216	72	21.6	7.2	2.16	0.72
H+9-H+10	0.065	195	65	19.5	6.5	1.95	0.65
H+10-H+11	0.057	171	57	17.1	5.7	1.71	0.57
H+11-H+12	0.051	153	51	15.3	5.1	1.53	0.51
H+12-H+13	0.046	138	46	13.8	4.6	1.38	0.46
H+13-H+14	0.042	126	42	12.6	4.2	1.26	0.42
H+14-H+15	0.040	120	40	12.0	4.0	1.20	0.40
H+15-H+16	0.036	108	36	10.8	3.6	1.08	0.36
H+16-H+17	0.033	99	33	9.9	3.3	0.99	0.33
H+17-H+18	0.031	93	31	9.3	3.1	0.93	0.31
H+18-H+19	0.030	90	30	9.0	3.0	0.90	0.30
H+19-H+20	0.027	81	27	8.1	2.7	0.81	0.27
H+20-H+21	0.026	78	26	7.8	2.6	0.78	0.26
H+21-H+22	0.025	75	25	7.5	2.5	0.75	0.25
H+22-H+23	0.023	69	23	6.9	2.3	0.69	0.23
H+23-H+24	0.022	66	22	6.6	2.2	0.66	0.22

For total dose between time periods indicated within structures, apply the following:

1. Frame house:
   First floor - 1/2 of outside
   Basement - 1/10 of outside
   Corner of Basement - 1/20 of outside
2. Multistory reinforced concrete structure:
   Lower floors (away from windows) - 1/10 of outside
   Basement (surrounded by earth) - 1/1000 of outside

3. Shelter below grade with 3 feet of earth - 1/1000 of outside

To obtain the total dose for a specific contour between a specified time period, multiply the dose factor by the dose rate at H+1 for the contour desired. Example: Find the total dose for contour 2 between H+4 and H+5. Solution: Dose factor for time period H+4 and H+5 is 0.170x1000r/hr at H+1 (contour 2) = 170r (answer).

Table 7.3

Total Dose From Time of Arrival of Fallout Thru H+24 Hours

Outside

From Time of Arrival of Fallout Thru 24 Hours	Contour 1 (3000r/hr at H+1)	Contour 2 (1000r/hr at H+1)	Contour 3 (300r/hr at H+1)	Contour 4 (100r/hr at H+1)	Contour 5 (30r/hr at H+1)	Contour 6 (10r/hr at H+1)
H+ 1 - H+24	7,500	2,500	750	250	75	25.0
H+ 2 - H+24	5,193	1,731	519	173	52	17.3
H+ 3 - H+24	—	1,331	399	133	40	13.3
H+ 4 - H+24	—	—	339	113	34	11.3
H+ 5 - H+24	—	—	288	96	29	9.6
H+ 6 - H+24	—	—	—	81	25	8.1
H+ 7 - H+24	—	—	—	71	22	7.1
H+ 8 - H+24	—	—	—	63	19	6.3
H+ 9 - H+24	—	—	—	—	17	5.6
H+10 - H+24	—	—	—	—	15	5.0
H+11 - H+24	—	—	—	—	13	4.4
H+12 - H+24	—	—	—	—	—	3.9
H+13 - H+24	—	—	—	—	—	3.4
H+14 - H+24	—	—	—	—	—	3.0
H+15 - H+24	—	—	—	—	—	2.6
H+16 - H+24	—	—	—	—	—	2.2
H+17 - H+24	—	—	—	—	—	1.9
H+18 - H+24	—	—	—	—	—	1.6
H+19 - H+24	—	—	—	—	—	1.3
H+20 - H+24	—	—	—	—	—	1.0
H+21 - H+24	—	—	—	—	—	0.7
H+22 - H+24	—	—	—	—	—	0.5
H+23 - H+24	—	—	—	—	—	0.3

Remarks: (a) Contour 1 is 300 times contour 6
Contour 2 is 100 times contour 6
Contour 3 is 30 times contour 6
Contour 4 is 10 times contour 6
Contour 5 is 3 times contour 6

(b) An "acute dose" is the total roentgens absorbed within 24 hours.

(c) A dash means the idealized fallout pattern contour has been completed and therefore not applicable.

(d) For total dose within structures apply the following:

1. Frame house:
   First floor - 1/2 of outside
   Basement - 1/10 of outside
   Corner of basement - 1/20 of outside
2. Multistory reinforced concrete structures:
   Lower floors (away from windows) - 1/10 of outside
   Basement (surrounded by earth) - 1/1000 of outside
3. Shelter below grade with 3 feet of earth - 1/1000 of outside.

Table 7.4

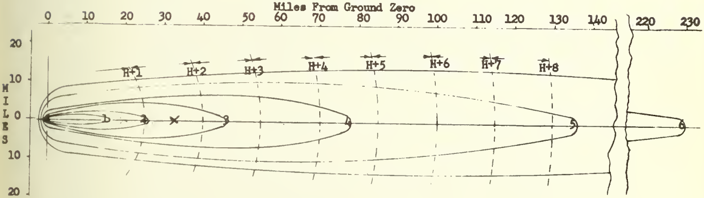
At the end of 24 hours after the detonation of a surface burst, most of the "local fallout" will have descended. The following depicts, for illustration purposes only, the arrival times of fallout and the contours for a 1 MT surface burst.

Schematic Illustration

of

Fallout Contours and Arrival Times

1 MT - 50% Fission - 50% Fusion
(15 MPH Effective Wind)



For exercise purpose only, estimates of casualties within the fallout areas, as of H plus 24 hours, may be obtained by use of casualty multipliers for the various fallout contours. The casualty multipliers for a total dose received in one day are as follows:

Radiation Sickness and Death
(Total radiation dose over the whole body
received in one day)

Total Dose (r)	Radiation Sickness (Percent)	Die (Percent)
0-75	0.0	0.0
100	2.0	0.0
125	15.0	0.0
150	25.0	0.0
200	50.0	0.0
300	100.0	20.0
450	100.0	50.0
650	100.0	95.0

Calculating the outside dose for geographic points where populations are located within a fallout contour is extremely difficult. To facilitate the casualty estimation process, therefore, simplified procedures have been developed. For purposes of eliminating complex calculations, the following dose figures and casualty multipliers may be used for estimation purposes.

	OUTSIDE			FRAME HOUSE			BASEMENT		
	Dose(r) by H+24 Hours	Percentages		Dose(r) by H+24 Hours	Percentages		Dose(r) by H+24 Hours	Percentages	
Contour		Sick	Die		Sick	Die		Sick	Die
1	Over 5000	100.0	100.0	Over 2500	100.0	100.0	Over 500	100.0	50.0
2	Over 1300	100.0	100.0	Over 650	100.0	100.0	Over 130	15.0	0.0
3	650	100.0	95.0	325	100.0	20.0	65	0.0	0.0

To facilitate the casualty estimation process within fallout areas the following conditions have been assumed:

a. The H plus 24 hour dose figure for a contour applies to all of the population located within the area.

b. The H plus 24 hour dose figures for contours 4,5 and 6, in general, do not produce radiation sickness or fatalities. Therefore, when estimating casualties, the populations located in these contours are not considered.

c. The population remain within a contour from H-hour thru H plus 24 hours.

d. All individuals take cover -- within fallout shelters, house or basement. Dose figures and casualty percentage multipliers for a frame house or basement, therefore, should be used when developing estimates.

e. Recovery does not begin until H plus 7 days; the casualty percentage multipliers are not based on the "effective biological dose (EBD)".

f. Individuals receiving more than 1,000r will be fatalities within 1 week; individuals receiving 600r - 1,000r will be fatalities within 1 month.

g. Distance of fallout will vary with wind speed and weapon yield.

The following percentages will assist personnel to determine the number of individuals within basements and frame houses:

Area	Percent of Population	
	Within Basement	Within House
REGION 1		
Connecticut	80	20
Maine	80	20
Massachusetts	80	20
New Hampshire	80	20
New Jersey	80	20
New York	80	20
Rhode Island	80	20
Vermont	80	20
Puerto Rico	NA	NA
Virgin Islands	NA	NA
REGION 2		
Delaware	50	50
Dist. of Columbia	50	50
Kentucky	50	50
Maryland	50	50
Ohio	80	20
Pennsylvania	80	20
Virginia	50	50
West Virginia	50	50
REGION 3		
Alabama	10	90
Florida	10	90
Georgia	10	90
Mississippi	10	90
North Carolina	10	90
South Carolina	10	90
Tennessee	10	90
Canal Zone	NA	NA

Area	Percent of Population	
	Within Basement	Within House
REGION 4		
Illinois	80	20
Indiana	80	20
Michigan	80	20
Minnesota	80	20
Wisconsin	80	20
REGION 5		
Arkansas	10	90
Louisiana	10	90
New Mexico	10	90
Oklahoma	10	90
Texas	10	90
REGION 6		
Colorado	50	50
Iowa	80	20
Kansas	50	50
Missouri	50	50
Nebraska	80	20
North Dakota	80	20
South Dakota	80	20
Wyoming	80	20
REGION 7		
Arizona	10	90
California	10	90
Hawaii	NA	NA
Nevada	50	50
Utah	50	50
American Samoa	NA	NA
Guam	NA	NA
REGION 8		
Alaska	NA	NA
Idaho	80	20
Montana	80	20
Oregon	50	50
Washington	50	50

Casualty Estimation Form - Fallout Only

Casualty estimates within fallout areas only may be computed by use of the form entitled " Casualty Estimation Form - Fallout Only". Use of the form will enable personnel to develop the following estimates:

a. The population within each of the fallout contours.

b. The number of individuals located within basements and frame houses.

c. The number of individuals who will become sick from the radiation effects and the number who will eventually die.

d. The time-phasing for those individuals who eventually die.

Idealized fallout templates, depicting the various contours, may be used to train personnel in how to compute estimates of casualties within fallout areas only. Such devices, however, should not be used when a specific attack pattern is employed for exercise purposes or in the event of an enemy attack. During exercises, personnel should use for casualty estimation purposes the fallout pattern especially developed for the attack pattern designed for the exercise.

Casualty Estimation Form
(Fallout Only)

OCD Region: ________ State: ______________________________

Estimated Population

Contour 1	Contour 2	Contour 3
Dot Value: ________	Dot Value: ________	Dot Value: ________
No. of Dot: ________	No. of Dots: ________	No. of Dots: ________
Population: ________	Population: ________	Population: ________
In basement:	In basement:	In basement:
_____ % : ________	_____ % : ________	_____ % : ________
In house:	In house:	In house :
_____ % : ________	_____ % : ________	_____ % : ________

Estimated Casualties

House						Basement					
Contour	Population	Sick		Die		Contour	Population	Sick		Die	
		%	No.	%	No.			%	No.	%	No.
1		100		100		1		100		50	
2		100		100		2		15		0	
3		100		20		3		0		0	
Total		☒		☒		Total		☒		☒	

Anticipated Deaths by Time

House		Basement	
Contour	Time	Contour	Time
1	Within 7 days	1	Within 60 days
2	Within 30 days	2	None
3	Within 60 days	3	None

METHOD OF ESTIMATING DAY POPULATION

Operation	*Character and source of data*
Begin with 1960 resident population by census tracts or enumeration districts.	Final figures from the 1960 census of population.
Subtract residents in the labor force	Constructed from final 1960 census data.[1]
Subtract children in school	Constructed from final 1960 census data adjusted to independent total school enrollment.[2]
Subtract residents away from home for reasons other than school attendance or employment.	Constructed from data obtained locally, applied to total resident labor force, and distributed in accordance with nonworking, noninstitutional, nonschool population.[3]
Subtract institutional population	Determined from 1960 census data.

(Result of these subtractions gives an estimate of persons in their own homes during the day.)

Operation	*Character and source of data*
Add estimate of number of persons employed in area.	Estimate based on distribution of 1960 labor force (adjusted to include workers coming from beyond city limits) among districts in accordance with patterns of employment shown by Census of Manufactures and Census of Business.[4]
Add estimates of persons in school in area	Assumed equal to estimate of number of residents in area enrolled in school.
Add institutional population	Available in census records.
Add estimates of persons present for reasons other than employment or school attendance (transients in hotels and other visitors, shoppers, etc.).	Persons resident in city and away from home for these reasons adjusted to include groups coming from beyond city limits, and assumed to be in ratio to estimate of persons employed in business establishments.[5]

(Result of this computation is daytime population.)

Footnotes

[1] For all tracted cities the number of residents in the labor force is directly available by tracts from final 1960 census data. For all untracted cities the method of constructing 1960 labor force estimates for each enumeration district is as follows:

(*a*) Obtain number of residents 14 years old and over in each enumeration district from final 1960 census data.

(*b*) Add figures in (*a*) to obtain total number of residents 14 years old and over in city as a whole.

(*c*) Obtain the number of persons in the labor force for the city as a whole from final 1960 census data.

(*d*) Determine ratio of number of persons in labor force (*c*) to number of persons 14 years old and over (*b*) for city as a whole. This gives adjustment factor.

(*e*) Apply this adjustment factor to number of persons 14 years old and over in each enumeration district (*a*). This gives estimate of number of residents in the labor force in each enumeration district.

[2] Method of constructing estimates of children in school:

(*a*) Obtain number of children 5 to 17 years of age from final 1960 census data, by tracts for tracted cities or by enumeration districts for untracted cities.

(*b*) Add figures in (*a*) to obtain total number of children 5 to 17 years of age in city as a whole.

(*c*) Obtain from 1960 census sample data or from independent sources estimates of elementary and high school enrollment for 1960 for city as a whole.

(*d*) Determine ratio of school enrollment (*c*) to school-age children (*b*) for city as a whole. This gives adjustment factor.

(*e*) Apply this adjustment factor to number of school-age children for each tract or enumeration district (*a*). This gives 1960 estimate of school population for each tract or enumeration district.

[3] Method of estimating number of persons away from home for reasons other than school or employment:

(*a*) From data available locally obtain a factor describing the numerical relationship between such persons and the number of resident workers. (If such data are not available locally, use a factor of 40 percent. This factor was computed from data available in a few cities and may not be as accurate as a factor obtained from local data.)

(*b*) Apply this factor to the estimate of total labor force for the city to obtain estimated total number of persons away from home for other reasons.

(*c*) Distribute the estimate of total persons away from home for other reasons in proportion to the distribution by tracts of the population not in the labor force, in school, or institutions.

[4] Method of constructing estimates of persons employed in city:

(*a*) To allow for persons living outside the city limits who come into the city to work during the day, the following procedure was used:

1. (1) For a single central city in a standard metropolitan area, add one-half of the labor force residing outside the city limits but within the city's standard metropolitan area to the labor force residing in the city. This yields an estimate of the total number of persons working in the city.
2. (2) For "twin" central cities in a standard metropolitan area (e. g., St. Paul and Minneapolis), apportion one-half of the labor force residing outside the two cities but within the standard metropolitan area according to the number of persons employed in business establishments in each city (as determined from the Census of Business). Add these apportioned parts to the labor force residing in each city. This yields an estimate of the total number of persons working in the city.
3. (3) For clusters of large cities in a standard metropolitan area (e. g., Boston or New York), add to the number of persons employed in manufacturing establishments in the city, (as determined from Census of Manufactures, three times the number of persons employed in business establishments (as determined from Census of Business). This yields an estimate of total number of persons working in the city. The ratio of three to one is established as an average ratio of the number of persons working in all nonmanufacturing establishments to the number of persons reported working in those business establishments covered by the Census of Business.

(*b*) Divide this estimate of total persons working in the city into (1) persons employed in manufacturing (assumed to equal the number reported by Census of Manufactures), and (2) all other workers.

(*c*) Distribute the estimate of the number of persons employed in manufacturing in accordance with the estimated tract distribution of persons employed in manufacturing establishments (the latter estimate is based on data from the Census of Manufactures).

(*d*) Distribute the estimate of the number of workers not employed in manufacturing in accordance with the estimated tract distribution of persons employed in business establishments as reported by the Census of Business.

For Washington, D. C., divide the estimated number of workers not employed in manufacturing into government workers and others. Distribute the estimated number of government workers in accordance with a tract distribution estimated from local data. Distribute as in (*d*) above the estimate of the other persons not in government and not in manufacturing.

(*e*) Add the distributions in (*c*) and (*d*) to obtain an estimate of the district distribution for all persons working in the city during the day.

[5] Estimate of persons present for reasons other than employment or school attendance:

(*a*) To allow for "other persons away from home" whose residence is outside the city limits, increase the estimated city total for "other persons away from home" by a 30 percent factor. (This factor is based on data for a few cities.)

(*b*) Distribute the estimated number of "other persons away from home" in the city during the day in accordance with the distribution by tracts of persons employed in business establishments based on data from the Census of Business.

(*c*) Add to the estimated number of "other persons away from home" an estimate of the transient hotel population by tracts, based on records from the census showing location of hotels, from data on number of rooms from the Hotel Redbook and from an assumed rate of occupancy.

Important Assumptions

Certain assumptions had to be made in developing the procedure described in this appendix. Some of these assumptions have little actual supporting evidence but are considered valid. The more important of these are:

(*a*) The total number of residents of the city away from home for reasons other than school attendance and employment approximates 40 percent of the total resident labor force, and an increase in this number by 30 percent provides an adequate estimate of the number of persons in the city during the day who were away from their home outside the city. Since usable field data were obtained from only 3 or 4 cities on these points, the patterns might not apply to all the cities.

(*b*) The net number of persons in the city for reasons of employment approximates the total labor force of the city plus one-half the labor force of the standard metropolitan area outside the city.

(*c*) Employment in other than manufacturing follows the same area distribution as employment in business establishments reported by the . Census of Business.

(*d*) Nonworking and nonschool persons are present in an area in relation to the number of persons employed in business establishments.

(*e*) The current pattern of employment distribution is the same **as that shown in Census of Business and Census of Manufactures**

APPENDIX A

RESOURCES AND FEATURE MAPS NEEDED FOR ESTIMATION PURPOSES

The following table should serve as a guide in selecting the resources and features for which information must be collected. Depending on the requirements of the area making the estimates, additional resources and features may be added and some may be deleted. The specific information to be placed on the various maps and the supplementary information to be compiled should be determined by the area.

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
POPULATION & MANPOWER Population	Basis for estimating: a. survivors b. casualties c. shelter requirements d. requirements for survival-medical, housing, food, water and so forth	Distribution of population: a. resident b. day	None	a. Bureau of Census reports b. OCD, DOD c. Local estimates
MANPOWER Labor force and/or selected occupations	Basis for estimating availability of labor force and selected occupations for survival operations purposes	Distribution of labor force by broad industry group or selected occupation group	None	a. Bureau of Census reports b. Dept. of Labor reports c. Local estimates
Potential Manpower Sources Students and faculty in colleges and universities	Basis for estimating availability of manpower for survival operations purposes.	Locations of: a. colleges b. universities	a. name, address and geographic location, Number of: b. students c. medical students d. dental students e. engineering students f. graduate students g. faculty	a. The Education Directory, HEW b. Higher Education Directory, HEW c. Board of Education

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RESOURCES AND FEATURE MAPS NEEDED FOR ESTIMATION PURPOSES

The following table should serve as a guide in selecting the resources and features for which information must be collected. Depending on the requirements of the area making the estimates, additional resources and features may be added and some may be deleted. The specific information to be placed on the various maps and the supplementary information to be compiled should be determined by the area.

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
POPULATION & MANPOWER Population	Basis for estimating: a. survivors b. casualties c. shelter requirements d. requirements for survival-medical, housing, food, water and so forth	Distribution of population: a. resident b. day	None	a. Bureau of Census reports b. OCD, DOD c. Local estimates
MANPOWER Labor force and/or selected occupations	Basis for estimating availability of labor force and selected occupations for survival operations purposes	Distribution of labor force by broad industry group or selected occupation group	None	a. Bureau of Census reports b. Dept. of Labor reports c. Local estimates
Potential Manpower Sources Students and faculty in colleges and universities	Basis for estimating availability of manpower for survival operations purposes.	Locations of: a. colleges b. universities	a. name, address and geographic location, Number of: b. students c. medical students d. dental students e. engineering students f. graduate students g. faculty	a. The Education Directory, HEW b. Higher Education Directory, HEW c. Board of Education

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
HOUSING Dwelling units	Basis for estimating dwelling units lost and remaining after an attack	Distribution of dwelling units or number of rooms	None	a. Bureau of Censu reports b. Local estimates c. OCD,DOD
Facilities suitable for potential housing	Basis for estimating availability of space suitable for housing during survival period	Locations of: a. hotels b. motels c. halls d. clubs e. armories f. community centers g. public buildings h. institutions i. theaters j. other miscellaneous structures considered suitable for emergency housing	a. name and address and geographic location b. floor area (sq. feet)	a. Field Survey b. Trade Ass'n c. Planning Commission

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
COMMUNICATIONS Radio and TV Facilities	a. use in emergency as means of communication b. use for dissemination of public information	Location: a. AM,FM and TV (station and transmitter) b. Amateur (Ham) c. Special (utility, taxi, trucking, police, fire) d. state and municipal communications systems.	a. name and address and geographic location b. call letters c. assigned operating frequency d. power to antenna e. operation of station-day or night f. estimated coverage area g. assigned operating channel (for TV)	a. OCD, DOD b. Local trade Ass'n
Domestic teletype system	Use in emergency as means of communications	a. Location of offices b. cable and wire facilities overhead and underground	a. name and address and geographic location b. number of patrons	a. Western Union b. Teletypewriter directory c. OCD, DOD
Domestic telephone system	Use in emergency as means of communications	Locations: a. Central exchange b. Business offices c. Branch exchanges d. Principal cables e. Repair and maintenance facility	a. name, address and geographic location b. number of telephones served	a. Telephone Co. b. OCD, DOD

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
GOVERNMENT FACILITIES				
State-county-municipal facilities housing governmental organizations Emergency operating centers or relocation sites	Basis for estimating the availability of government facilities and personnel for directing and conducting defense operations during the survival period	Locations of governmental facilities	a. name and address and geographic location b. organization elements located in structure c. personnel d. types of supplies and equipment	a. Planning Comm. b. appropriate executive depts. at state-county and local levels.

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
FOOD				
Food on hand in household, retail stores, warehouses, wholesalers, eating places.	Basis for estimating availability of food for subsistance purposes.	Distribution of total supply of calories on hand for: a. household b. retail stores c. warehouses d. wholesalers e. eating places	None	OCD, DOD
Livestock on Farms	Basis for estimating availability of food for subsistence purposes.	Distribution of: a. no. of cattle and calves b. no. of hogs and pigs c. no. of sheep and lamb d. no. of milk cows e. no. of chickens f. no. of turkey hens	None	OCD, DOD, Bureau of Census reports County Agent, U.S. Dept. of Agriculture
Grain storage	Basis for estimating availability of food for subsistence purposes.	Locations of storage facilities	a. name, address and geographic location b. storage capacity (1,000's of bushels)	OCD, DOD Dept. of Agricultur

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
ENERGY-POWER-FUEL				
Electric power system	Basis for estimating availability of electric power during survival period for lighting, cooking and heating and operation of household appliances.	Locations of: a. generating stations b. transformer substations c. boundaries of service area d. repair and maintenance facilities	a. name, address and geographic location b. capacity of generators in 100's of kw c. capacity of transformers in 100's of kw d. list of equipment e. A.C. or D.C.	a. Power companies b. municipal power commission c. public, utility commission
Natual gas storage tanks and pipelines	Basis of estimating availability of natural gas for cooking and heating during survival period.	a. Location of storage tanks b. Repair and maintenance facilities c. Principal pipelines location-diameter-boundaries of service areas- loops or cross connections-main valves.	a. geographic location b. capacity	Gas companies
Solid fuel - Anthracite coal	Basis for estimating availability of solid fuel for cooking and heating during survival period.	Locations of wholesale and retail distribution facilities	a. name, address and geographic location b. tons on hand	Trade Associations OCD, DOD Coal companies

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
PETROLEUM PRODUCTS Storage capacity	Basis for estimating availability of fuel for transportation, cooking and heating during survival period.	Locations of storage terminals and bulk plants for: a. crude oil b. aviation gasoline c. motor gasoline d. kerosene e. distillate fuel oil f. residual fuel oil g. liquified petroleum gas	a. name, address and geographic location b. capacity in 100's of barrels c. no. of trucks d. capacity of trucks in 100's of barrels	OCD, DOD oil companies

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
HEALTH Medical care facilities: Hospitals Nursing homes Health centers, clinics Prepositioned civil defense emergency hospitals	Basis for estimating availability of health facilities for treatment of patients	Locations by type of facility: a. regular b. mental c. civil defense emergency d. nursing home e. clinics f. health centers g. VA domiciliaries and hospitals	a. name and address and geographic location b. rated bed capacity c. current bed capacity d. expanded bed capacity e. average daily census f. total personnel g. annual outpatient visits h. size and composition of staff for each facility	Health dept. Medical Ass'n American Hospital Ass'n Public Health Service OCD, DOD
HEALTH MANPOWER	Basis for estimating availability of health manpower for post-attack needs	Distribution of: a. medical doctors b. doctors of osteopathy c. dentists d. veterinarians e. nurses f. pharmacists g. sanitary engineers h. sanitarians	None	American Medical Ass'n American Osteopath Ass'n American Dental Ass'n American Vetgnarian Medicine Ass'n American Nurses Ass'n American Pharmaceutical Ass'n National Science Foundation OCD, DOD

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
cont'd Veterans Administration Facilities	Basis for estimating availability of health facilities for treatment of patients	Location of: a. Hospitals b. Domiciliaries c. outpatient clinics d. supply depots	a. name and address. and geographic location b. operating beds c. emergency beds d. total personnel e. doctors f. dentists g. nurses	a. OCD, DOD b. Veterans Administration
Medical Professional buildings	Source of health, manpower, equipment and supplies	Locations of buildings	a. name and address and geographic location b. bed capacity cc.medical doctors d. doctors of osteopathy e. nurses f. pharmacists gg.types of supplies	a. local medical association b. city directory c. hospitals
Health Supplies and Equipment	Basis for estimating availability of health supplies and equipment survival items considered required during the survival period	Locations of: producers wholesalers warehouses of a. dressings b. anti-biotics; biologicals c. serums d. blood collecting & dispensing supplies e. surgical instruments f. pharmaceutical g. common use items	a. name and address and geographic location b. inventory on hand	a. Chamber of Commerce b. Business and Trade Ass'ns c. Field Survey

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
TRANSPORTATION				
Water - port facilities	Basis for estimating availability of water transportation facilities for evacuation, shipment of equipment, supplies or personnel	Locations of piers	a. name, address and geographic location b. no. of berths c. no. of pier superstructures d. no. of hatches workable e. transit shed floor space (1000's sq.ft.) f. no. of petroleum tanks connected to pier g. storage capacity of tanks h. special handling facilities: general and bulk gargo grain petroleum ore coal other	a. Port authority b. steamship lines c. municipal, engineer, planning board d. Corps of Engineers U.S. Army
Inland Waterways locks lock and dam combination	Basis for estimating availability of inland waterways for transportation purposes	Locations of: a. locks b. lock and dam combination	name, address and geographic location	a. Port Authority b. Corps of Engineers, U.S. Army
Maritime Reserve Fleet	Basis for estimating availability of ships	Locations of anchorages of reserve fleet	geographic location no. of ships by type tonnage	U.S. Maritime Administration

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
TRANSPORTATION				
Rail Railroads	Basis for estimating availability of rail transportation facilities for evacuation, shipment of equipment, supplies or personnel	Locations of: a. bridges b. tunnels c. causeway d. viaduct e. terminals or stations f. classification yards g. repair shops h. main lines and alternate routes	a. name, address and geographic location of bridges, tunnels, causeway, viaduct, stations, yards, repair shops b. yards: freight car capacity; average number of freight cars on hand daily; normal number of freight cars lime-haul locomotives switching locomotives, on hand c. bridge, tunnel, causeway or viaduct: length; average number of freight and passenger trains daily d. repair shops, wrecking equipment on hand e. type of power: (steam, diesel, electric)	Railroad offices Association of American Railroads Interstate Commerce Comm.

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
TRANSPORTATION				
Air Civil airports	Basis for estimating availability of air transportation for emergency use	a. Location b. type (public or private)	a. name, address and geographic location b. length of runway c. maintenance facilities d. fuel supplies on hand e. fire and crash equipment f. surface of runway (paved or turf) g. availability of runway lights and beacons h. no. of based aircraft i. no. of based multi-engine aircraft	Civil Air Patrol Federal Aviation Agency Airline companies

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
TRANSPORTATION Highway Streets and highways	Basis for estimating availability of routes for evacuation, mobile support, movement of equipment, supplies or personnel	Location of: a. main highways b. traffic signals c. overpass and underpass d. overhead power and trolley wires e. traffic bottleneck f. road sections subject to flooding	goegraphic location of overpass and underpass	a. municipal street department b. state highway department c. traffic engineer
Streetcars, trolleys buslines and vehicle storage yards	Basis for estimating availability of routes and vehicles for evacuation, movement of supplies or personnel	a. routes b. type (surface, elevated, underground) c. Power supply (trolley line, third rail) d. location of vehicle storage yard e. repair and maintenance facilities	storage yard: a. geographic location b. number of vehicles on hand c. capacity of vehicles	a. Transit Company b. Power Company c. Municipal planning Commission
Motor vehicle distributors (new and used cars) and garages	Basis for estimating potential sources of vehicles for emergency use	Locations of: a. Distributors b. garages	a. name, address, and geographic location b. number of types of vehicles on hand c. repair facilities	Autodealers Ass'n
Motor Trucks	Basis for estimating potential sources of motor vehicles for emergency use	Location	a. geographic location b. total trucks c. petroleum trucks d. farm trucks e. other trucks	OCD, DOD Transport Ass'n Motor Truck Companies

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
Highway Bridges crossing waterways, causeways, viaducts and tunnels	Basis for estimating availability of routes for shipment of essential civilian supplies and equipment for emergency use.	Location	a. geographic location b. length of span c. type of construction d. load capacity e. clearance (horizontal and vertical)	a. OCD, DOD b. Bureau of Public Roads c. Municipal and State highway department

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
WATER SUPPLY - DISTRIBUTION SYSTEM AND AUXILIARY SOURCES				
Reservoirs - Dams - flumes - Pumping stations - treatment plants - intake towers - wells-mains - water towers	Basis for estimating availability of water for fire control, domestic purposes, drinking and other emergency uses during the survival period	Location of: a. dams b. flumes, open channels c. reservoirs d. pumping stations e. intake towers f. filter stations g. source of power h. principal mains (diameters, pressures, type of pipe) i. valves (time of operation) j. potential sources (wells and water-towers, source of power, capacity) k. major repair equipment l. bactericidal facilities	a. geographic location b. supply improvements (millions of gallons) c. supply flow (gallons daily) d. supply pumping (gallons daily) e. treatment (gallons daily) f. distribution storage (gallons) g. distribution pumping and flow (gallons daily) h. Population served i. no. of repair crews (valve service; minor and major repair) j. inventory of major repair (type-equipment) k. bactericidal facilities (type-capacity-mobility-amount of chemical reserves).	a. Water department or company b. Publications of National Board of Fire Underwriters c. Health department d. Public Health Service e. Municipal Water Facilities Inventory publication

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
WELFARE FACILITIES				
Welfare	Basis for estimating availability of facilities and personnel for performing welfare activities during the survival period	Location of: a. state welfare offices b. local welfare offices c. welfare institutions such as: homes for the blind, homes for the aged, homes for the infirm, orphanages, centers for children, dental clinics, eye clinics, other types.	a. name, address and geographic location b. total employed c. no. of employees in welfare positions d. public or private e. type of welfare service	a. DHEW b. Council of social agencies

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
FIRE FACILITIES				
Fire stations and communications systems	Basis for estimating availability of fire apparatus, equipment and personnel for fire control operation.	Location of: a. all fire stations b. fire stations with broadcasting facilities c. transmitter d. switchboard of signal system	a. name and aumber of station b. geographic location c. personnel per shift d. total personnel all shifts e. list of apparatus and equipment at each station f. power output of radio g. frequency h. no. of auxiliary personnel	a. Fire Dept. b. Reports of National Board of Fire Under-Writers

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
LAW ENFORCEMENT FACILITIES				
Police stations and communications system	Basis for estimating availability of law enforcement personnel for police operations	Locations of: a. all police stations b. state highway patrol stations c. police stations with broadcasting facilities d. transmitter	a. name and number of precinct b. geographic location c. personnel per shift d. total personnel all shifts e. power output of radio f. frequency g. no. of auxiliary personnel	a. Police Dept. b. State Highway Patrol c. County Sheriffs
State Highway Patrol Facilities and Communications system				
County sheriff's offices				

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
ELEMENTARY AND SECONDARY SCHOOLS				
Elementary and secondary schools	Basis for estimating availability of educational facilities for civil defense emergency use	Location of: a. school buildings	a. name, address and geographic location b. number of pupils c. basement d. instructional rooms e. library f. auditorium g. cafeteria or lunch room h. gymnasium i. no. of employees j. no. of teachers k. bathroom facilities	a. OCD, DOD b. Dept. of Education

Resource of Feature	Significance	Information on Map	Supplementary Information	Suggested Sources
PUBLIC FALLOUT SHELTER				
Spaces	Basis for estimating approximate population located within the various types of public shelters	Distribution of shelter spaces by protection factor: Category — Protection Factor 8 — over 1,000 7 — 500-1,000 6 — 250-499 5 — 150-249 4 — 100-149 3 — 70-99 2 — 40-69 1 — 20-39	None	OCD, DOD

Forms may be designed for recording the desired supplementary information. The forms should provide columns for recording the code symbol on the map, identification, desired information.

Appendix B

Supplementary Information on Maps

Components of a Map B-1

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COMPONENTS OF A MAP

Maps usually show an irregular area fitted to a rectangular page or sheet. The composition of the sheet varies with each map; however, the components or make-up do not differ too much from map to map.

The basic components of a map are: title, legend, border, scale, parallels and meridians, compass roses, insets, accessories, graphic descriptions, symbols and lettering.

Title - The title block of a map may designate (a) the name of the land area represented (b) the type of map (c) the author (d) the year of preparation (e) the scale (f) other pertinent remarks.

Legend - The terms "legend", "key" or "explanation" on a map all refer to the explanation of symbols or abbreviations used on a map. Short legends are often included in the title block; extensive legends are often placed separately - usually at the bottom of a map. Symbols for obvious features, such as roads, boundaries and so forth, are often not explained in the legend; standard abbreviations are also not explained in the legend. Unusual abbreviations, however, are explained in the legend.

Border - Maps are usually framed within a border. The border, rectangular in shape, may be simple -- consisting of a single line or two or more parallel lines — or decorative. On many city maps, the border is frequently used for indicating coordinates which may be coded. The code and the street index enable one to locate a specific street.

Parallels and Meridians - Parallels (latitude lines) and meridians (longitude lines) are often omitted on simple maps. If the parallels and meridians are omitted then a compass rose or north arrow is substituted for the lines. Where they are included on a map, they are often designated along the borders in terms of degrees, minutes, and seconds. In maps employing strongly curved parallels, the entire projection system is usually shown in order to indicate the distortion and to assist in a better reading of the map.

Compass Roses - Where a map is oriented other than to the north and the parallels and meridians are not drawn, then a compass rose or north arrow, or other graphic device showing the north direction is often included on a map. On large-scale maps, it is usual to indicate the true north by a star; while the magnetic north by a half arrow and to state the exact amount of the magnetic declination.

Inset - An inset is an independent small map on a large scale map, having its own border, latitude and longitude, title and so forth. It is shown on many maps for one of the following reasons: (a) to show a significant portion of the main map on a large scale, (b) to show a small-scale general map for locating the area shown in the main map, or (c) to show an extended area of the main map which is drawn separately as an inset to save space.

Accessories - Topographic sheets have many accessories shown outside the border which are usually not found on ordinary simple maps. Some of these accessories are:

(a) general title
(b) name of sheet
(c) series number of sheet
(d) fractional scale
(e) graphic scale showing feet and miles
(f) diagram showing adjoining sheets
(g) synoptic key - an outline map of political divisions
(h) column of altitude tints
(i) list of definitions and abbreviations
(j) key to conventional signs
(k) list of authorities
(l) names of persons and offices responsible for the map
(m) date of preparation
(n) copyright notations

On city maps, an additional component is the street index. The index, in conjunction with the coordinate system, permits the location of a specific street.

TYPES OF MAPS

The process of classification involves the systematic arrangement of a subject into classes, groups or categories based upon some definite scheme. However, many schemes can be used for classifying maps, such as classifying them according to: (a) sheet size (b) method of reproduction (c) use or purpose (d) scale (e) manner in which the map is portrayed (f) elements of the content (g) area covered and (h) other. For purposes of classifying civil defense maps, the schemes employed in this document are based on the principal characteristics of maps. These characteristics are: (1) maps are primarily proportionate (2) maps are conventionalized pictures of portions of the earth's pattern as seen from above and (3) maps present pictures in a manner that their elements may be plainly visible. Civil defense maps therefore can be classified with reference to:

a. their scales
b. their conventionalized pictures
c. their elements or content

Maps Classified According to Scale

The scale of a map is the relationship between distance on a map and distance on the ground expressed as a fraction or ratio. Therefore, if the scale on a map is shown as 1:25,000 - $\frac{1}{(25,000)}$ - it means that one inch on the map equals 25,000 inches on the ground.

Maps classified with reference to their scales can be grouped into two categories: (1) small scale maps, and (2) large scale map. Maps having representative fractions from 1:62,500 and above are small scale maps; maps having representative fractions up to 1:62,500 are large scale maps. The following considerations influenced the selection of the representative fraction 1:62,500 to distinguish small from large scale maps: (1) the land area covered, and (2) the amount of detail shown on maps. An analysis of maps - United States, State, County and City - indicated:

a. maps having scales over 1:62,500 usually show large land areas, such as land areas of States, Counties and Minor Civil Divisions and a limited amount of detail,
b. maps having scales up to and thru 1:62,500 usually show comparatively small land areas, such as land areas of cities and a great amount of detail.

Two cartographic scaling principles are involved: (1) the amount of area shown on a map is inversely proportional to the value of the representative fraction. The smaller the scale -- the larger the land area shown; the larger the scale — the smaller the land area shown. (2) The amount of detail on a map is directly proportional to the value of the representative fraction. The smaller the scale -- the less the detail; the larger the scale -- the greater the detail. To illustrate the above principles: if two maps were compared -- one having a 1:25,000 scale and the other a 1:62,500 scale, the map with the 1:62,500 scale has a smaller scale, covers more land area and shows less detail than the map with the 1:25,000 scale. In other words, given two maps of the same sheet size, one map having a large scale and the other a small scale, it is the larger scale map which covers the smaller area of terrain but in greater detail than on the small scale map.

Although maps are printed on different sheet sizes, it is the scale and not the sheet size that determines the size of area and amount of detail shown on a map.

Maps showing land areas for minor civil divisions, counties, states and regions as well as United States maps usually are small scale maps, having scales ranging from 1:62,500 to 1:5,000,000 or more.

Typical characteristics of small scale maps are: (a) they show large land areas and (b) they show a minimum number of pieces of information. Most small scale maps usually show:

a. the names and boundaries of states
b. the names and boundaries of counties within states
c. the names and locations of cities
d. the names and locations of rivers, lakes and other waters
e. two or three additional special pieces of information, such as: railroads, highways, airfields, and so forth.

Federal, State and County civil defense planners will find small scale maps useful for indicating the following:

a. the locations of target areas
b. the boundaries of civil defense Regions or areas
c. The mutual aid and mobile support boundaries and areas
d. the locations of fixed support facilities
e. the boundaries of fallout areas
f. the boundaries of areas to be evacuated
g. the evacuation route patterns
h. the boundaries of reception areas and locations of reception facilities
i. the locations of specific critical features, such as: key facilities, bridges, communications facilities, and so forth.

Small scale maps can be utilized by local civil defense planners for indicating the following:

a. the relative location of their community in relation to target areas
b. the location of their community in relation to a probable pattern of attack
c. the boundaries of mutual aid and mobile support areas for their community

d. the fixed support facilities for their community
e. the boundaries of fallout areas for their community
f. the boundaries of areas into which their population would be evacuated
g. the evacuation route patterns
h. the locations of reception facilities.

Maps showing the details of a block, a section of a city or a city and its urban fringe areas are examples of large scale maps. The scales of large scale maps vary according to the area covered on the map. A block map may have a scale of one inch equals 100 feet, or 1:1,200 inches. (See Map Making For Wardens, Warden Training Bulletin Number 9, October 1952, page 3) A map showing a section of a city, such as Sanborn maps, may have scales 1:600 inches or one inch equals 50 feet. A map for a city and its urban fringe areas may have a scale ranging from 1:11,520 inches to 1:50,000 inches.

Typical characteristics of large scale maps are: (a) they show small land areas and (b) they show a great number of pieces of information. City block maps may show as many as 35 different pieces of information. Sanborn maps, which usually show a section of a city, also show as many as, and sometimes more than, 35 pieces of information. City maps usually show the following types of information:

a. the corporate boundaries of the city
b. the limits of the urban fringe areas
c. the street pattern
d. the blocks and their names
e. the rivers and lakes and their names
f. the parks and their names
g. the railroads, their facilities and names
h. the airports
i. the cemeteries
j. the recreational areas - golf courses, country clubs
k. the theaters
l. the hotels
m. the clubs
n. the air line offices
o. the bus lines - depots and routes
p. city offices
q. state offices
r. federal offices
s. churches
t. schools
u. hospitals
v. house numbering scheme
w. postal zones boundaries.

Each individual different piece of information on a city map is not always graphically depicted. In some instances, a city map will show a listing of churches, hospitals, schools, and so forth. Where a map does show a listing, the actual location of each facility can easily be spotted on the map.

Federal, State and County civil defense planners will find large scale maps of limited value in their planning tasks. Where a County, State or Federal planner desires to determine the impact of an atomic attack upon a specific community, then the large scale map will be found very useful.

Large scale maps can be utilized by local civil defense planners for the following planning purposes:

a. To graphically indicate the resources and hazards in a city block (Warden Block Maps)
b. To graphically depict an analysis of an urban area (civil defense urban analysis)
c. to indicate the organization of the ground (web defense)
d. To graphically depict the scheme of action to be followed during an emergency (operational maps should be prepared by each Service)
e. to indicate the areas to be evacuated
f. to indicate the evacuation route pattern
g. to graphically depict the boundaries of civil defense areas.

MAP SCALES

A map is a proportional representation of a portion of the earth's surface and its pattern. This proportion is called a scale. In an ordinary picture, the scale is usually obvious since the picture is not very much smaller or larger than its object. A map, however, is many thousand or million times smaller than the corresponding part of the earth's surface. This relationship, being beyond recognition, therefore must be stated on the map in the form of a scale. The scale indicates the relation between distance on the map and actual distance on the ground.

Scales, on maps, are usually represented in one of three different ways:

a. Fractional Scale - The proportion between the length of a line on the map and the corresponding length on the earth's surface is given in the form of a fraction. Example:

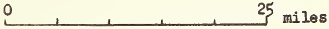
Scale: $\frac{1}{250,000}$ or 1:250,000

b. Verbal Scale - An inch on the map is indicated to correspond to a certain number of miles. This form is usually found on topographic sheets. Example:

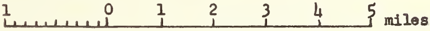
Scale: 1 inch to 4 miles
(Not: 1 inch = 4 miles)

c. Graphic Scale - The mileage is indicated on the map in the form of a graduated line or ruler. A graphic scale remains true even after the map has been reproduced by photographic process.

Scale:



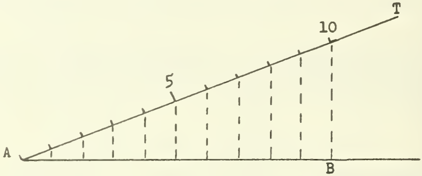
Scale:



On some maps, an extension on the left end of the bar or graphic scale is divided into tenths. Extensions enable one to measure distances more accurately; however, on small scale maps, they give a false impression that any distance on the map can be measured exactly. No map can be true to scale in every part or in every direction. On large scale maps, the distortion of the scale is usually small; on small-scale maps, such as those for countries or continents, the given scale may often be quite wrong, especially in the corners of the map.

Method of Dividing a Graphic Scale into Equal Parts

A method of dividing a graphic scale into ten equal parts is as follows:



Problem: To divide line AB into 10 equal parts.

Solution:
(a) Draw line AT at an agle from A.
(b) On line AT, measure off 10 equally spaced divisions, so that line AT is not much longer or shorter than line AB.
(c) Then, draw a line between B and 10.
(d) Parallels to B-10 will divide line AB into 10 equal parts.

This same principle may be applied in dividing a graphic scale to any number of divisions.

Method of Transforming One Type of Scale to Another Type of Scale

To transform one type of scale into another type, it is necessary to know the following:

a. Scale - $\frac{\text{distance on map}}{\text{distance in nature or on ground}}$
b. 1 mile equals 63,360 inches

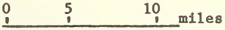
Three examples of transforming a scale are:

a. Problem: Given the fractional scale - 1:250,000, find the inch-to-mile scale.

Solution:
(a) One inch on the map corresponds to 250,000 inches on the ground.
(b) Since there are 63,360 inches in one mile, divide 250,000 inches by 63,360 inches or $\frac{250,000}{63,360}$ which will give 3.95, or approximately 4 miles.
(c) Thus, one inch on the map corresponds to approximately 4 miles on the ground.

b. Problem: Given a graphic scale (see illustration below), find the fractional scale

Given graphic scale



Solution:
(a) With a ruler, measure off one inch and determine the miles it represents. (In the illustration, one inch represents 5.5 miles)
(b) Multiply 5.5 miles by 63,360 inches which equals 348,480 inches.
(c) The numerical scale, therefore, is 1:348,480 or $\frac{1}{348,480}$.

c. Problem: Given the verbal scale, such as one inch corresponds to 16 miles, draw the graphic scale and determine the numerical scale.

Solution:
(a) To draw the graphic scale, obtain a ruler and measure off one inch. This corresponds to 16 miles.
(b) To determine the numerical scale, multiply 16 miles by 63,360 inches which equals 1,013,760 inches. Thus, the numerical scale is 1:1,013,760 or $\frac{1}{1,013,760}$.

If a map has no scale, the following procedure may be used to determine its scale:

a. Measure the distance of 1 degree in the center of the map or preferably on a straight meridian to determin its length in inches.
b. Since 1 degree of latitude equals on the average 69 miles, divide 69 miles by the inches obtained to determine how many miles one inch on the map corresponds to miles.

c. Multiply the inch-to-mile figure obtained by 63,360 inches to determine the numerical scale.

Example: Assume 1 degree of latitude on a map is 2.3 inches long. The scale, therefore, will be 1:1,900,800. (Since 2.3 inches on the map is 69 miles, then by dividing 69 miles by 2.3 inches we find one inch corresponds to 30 miles. We then multiply 30 miles bb 63,360 inches and obtain 1,900,800 inches. There, the numerical scale is 1:1,900,800 or $\frac{1}{1,900,800}$.)

The following tables will be found useful in solving map scaling problems.

DERIVATION OF MATHEMATICAL DATA

One Inch on Map:

To obtain inches divide inches by 1 inch.
To obtain feet divide inches by 12 inches.
To obtain yards divide inches by 36 inches.
To obtain meters divide inches by 39.37 inches.
To obtain miles divide inches by 63,360 inches.

One Centimeter on Map:

To obtain inches divide inches by 2.540 inches.
To obtain feet divide inches by 30.487 inches.
To obtain yards divide inches by 91.575 inches.
To obtain meters divide inches by 100 inches.
To obtain miles divide inches by 156,250 inches.

CONVERSION FACTOR TABLE

Multiply	By	To Obtain
centimeters	.03281	feet
centimeters	.3937	inches
feet	30.48	centimeters
feet	.3043	meters
inches	2.540	centimeters
inches	.08333	feet
meters	100	centimeters
meters	3.281	feet
meters	39.37	inches
meters	1.094	yards
miles	5280	feet
miles	63,360	inches
miles	1760	yards
yards	3	feet
yards	36	inches
yards	.9144	meters

MAP DISTANCE EQUIVALENCE TABLE

Distance Map	Ground Distance	$\frac{1}{25,000}$	$\frac{1}{50,000}$	$\frac{1}{75,000}$	$\frac{1}{100,000}$
One Inch =	Inches	25,000	50,000	75,000	100,000
	Feet	2,083	4,167	6,250	8,333
	Yards	694	1,389	2,083	2,778
	Meters	635	1,270	1,905	2,540
	Miles	.4	.8	1.2	1.6
One Centi-meter =	Inches	9,843	19,685	29,528	39,370
	Feet	820	1,640	2,460	3,281
	Yards	273	547	820	1,094
	Meters	250	500	750	1,000
	Miles	.16	.3	.5	.6

Distance Map	Ground Distance	$\frac{1}{200,000}$	$\frac{1}{250,000}$	$\frac{1}{500,000}$	$\frac{1}{1,000,000}$
One Inch =	Inches	200,000	250,000	500,000	1,000,000
	Feet	16,667	20,833	41,667	83,333
	Yards	5,555	6,944	13,888	27,776
	Meters	5,080	6,350	12,700	25,400
	Miles	3.2	4	8	16
One Centi-meter =	Inches	78,740	98,425	196,850	393,700
	Feet	6,562	8,202	16,404	32,808
	Yards	2,187	2,734	5,468	10,936
	Meters	2,000	2,500	5,000	10,000
	Miles	1.2	1.5	3	6

MAP PROJECTIONS

Since the government maps, recommended by OCDM for use for civil defense planning, employ the Polyconic, Transverse Mercator and Lambert Conformal Conic projections, questions may arise among users concerning these projections. The questions may pertain to:

1. The basic properties of the several projections.
2. The legitimacy of combining, in a single map, data based on more than one projection.
3. The ease of matching adjoining sheets (quadrangles) to form a map of a larger area.

In this chapter, therefore, an attempt will be made to clarify the relationship between the projections and answer some of the questions that may arise.

It is impossible to represent a portion of a spherical surface on a plane sheet without some distortion. Many types of projections, therefore, have been devised for mapping the earth's surface and at the same time keeping the resulting distortion within permissible limits. Each projection has its own advantages and disadvantages. No one system is superior to all others in every respect. The choice of projection for a particular map depends on (1) the size, shape and location of the area to be mapped, (2) the scale of the proposed map and (3) the use to which it is to be put. For a small area, many projections are available in which the distortion can be kept within such small limits that it is impossible to distinguish between them. As the area to be mapped increases in size, the distortions inherent in the various projections become increasingly significant. It is then necessary to choose a projection which will best suit the particular need. When the area is too large to be represented conveniently on a single sheet at the map scale selected, it must be divided into smaller areas. The projection, then, must be such as to permit the joining of adjacent sheets so that corresponding edge details will match properly.

Three projections will be discussed:

1. The Polyconic projection - used for the United States Geological Survey quadrangles; Scale - 1:125,000; 1:62,500 and 1:24,000 or 31,680.
2. The Transverse Mercator - used for the Army Map Service and quadrangles; (Scales 1:250,000; 1:100,000; 1:50,000; 1:25,000) and the United States Geological Survey 1:250,000 scale quadrangle sheets.
3. Lambert Conformal Conic - used for the Army Map Service and United States Geological Survey sheets - scale 1:500,000.

Polyconic Projection

The polyconic projection has been generally accepted as the best for a small regular shaped area such as shown on a United States Geological Survey Quadrangle - scale 1:125,000; 162,500; 124,000 or 1:31,680. In this projection, the earth's surface is projected onto an infinite number of cones, each tangent to the ellipsoid at its own parallel of latitude. The developed parallels, therefore, are true circles, each of a different radius, and each centered at a different point on the extension of the central meridian of the projection. The central meridian is a straight line; all other meridians are slightly concave toward it. Scale is true along the central meridian and along each parallel of latitude; at all other points, and in other directions, the scale is slightly exaggerated. Although the polyconic projection does not comply strictly with most of the desirable specifications for a map projection, that is it is not conformal, the scale is not uniform, the shapes and areas are not retained exactly, it nevertheless comes closer to compliance with more of these specifications than any other available projection. The distortions are kept to a minimum in all parts of the map sheet, and for small areas, the earth's surface may be represented with a greater fidelity on this projection than on any of the others. On a United States Geological Survey quadrangle sheet, the distortions are so small that it is impossible to plot or measure them at map scale. Thus, for practical purposes, a single United States Geological Survey quadrangle may be considered a true portrayal of that portion of the earth's surface.

Mercator and Transverse Mercator Projections

The Mercator is a cylindrical type projection which is mathematically derived. The meridians appear as vertical straight lines which are equidistant and parallel. The parallels of latitude appear as horizontal straight lines which are parallel to one another and perpendicular to the meridians. Their distance apart increases with an increase in latitude.

On the earth, meridians converge toward the poles; yet, on the Mercator Chart, they appear as parallel. On the chart, therefore, the east-west scale is increased so that it is twice as great at the 60° parallel as it is at the equator. Consequently, the parallels must be spaced in such a manner on the chart that the north-south scale increases in the same proportion. Thus, parallels which are the same distance apart everywhere on the earth; are shown twice as far apart at 60° as at the equator. Their distance apart increases progressively with their distance from the equator. As a result, the scale at any point is constant in all directions.

The meridians and parallels are shown as intersecting at right angles on the chart just as on the earth. Likewise, all other angles are correctly shown. This means that shapes are correctly shown within small areas, though the expanding scale causes distortion of shape over large areas.

Since scale is uniform in all directions at any point, and since angles are correctly shown, the Mercator projection is conformal. Every rhumb line appears as a straight line, and every straight line is constant in direction.

The equator and the meridians are the only great circles which appear as straight lines; all other great circles appear as curved lines.

For the Transverse Mercator projection, picture a portion of the earth's surface projected onto the developed surface of a tangent cylinder with its axis in the plane of the equator (See Figure 4), so that the line of tangency is the central meridian of the area. Then, reduce the scale of projection slightly so that it will be too small in the region of the central meridian. The scale will then be exact along two lines parallel to the central meridian and spaced symmetrically on both sides of it. In the entire region between these two parallel lines, the scale will be too small; in the region beyond them, it will be too great. The mapped area may be extended without limit in the north-south direction, but is restricted to narrow limits in the east-west direction. Scale distortions increase rapidly as the distance increases beyond these parallel lines. The transverse mercator projection is limited to relatively narrow north-south bands.

Lambert and Lambert Conformal Conic Projection

The Lambert projection portrays a portion of the earth's surface on the developed surface of secant cone. Along the two parallels of latitude at which the cone cuts the spheroid, the scale is exact. In the area between these parallels, the map scale will be too small, and in the area outside these parallels, it will be too great. The mapped area may be extended without limit in the east-west direction, but is restricted within narrow limits in the north-south direction. Scale distortions increase rapidly as the distance increases beyond the two standard parallels. The use of this projection, therefore, is limited to relatively narrow east-west bands. Principal advantages of this projection are: (1) scale distortions are systematic and can be predetermined (2) a map sheet of any portion of a zone can be matched perfectly with an adjoining sheet in the same zone. A map of one zone, however, cannot be matched with a map of an adjoining zone.

The Lambert Conformal Conic is a conical type projection in which all meridians are straight lines meeting at a common point beyond the poles, and all parallels are concentric circles whose center is the point of intersection of the meridians. Meridians and parallels intersect at right angles and the angles formed by any two lines on the earth's surface are correctly represented on this projection.

It employs a cone intersecting the spheroid at two parallels known as the standard parallels for the area to be represented. In general, for equal distribution of scale error, the standard parallels are chosen at one-sixth and five-sixths of the total length of that portion of the central meridian to be represented. It may be advisable in some localities, or for special reasons, to bring them closer together for greater accuracy in the center of the chart at the expense of the upper and lower border areas.

On the two selected parallels, arcs of longitude are represented in true scale. Between these parallels the scale will be too small and beyond them too large. The projection is especially suited for charts of dominantly east-west dimension.

Four degree bands are now in use, placing the standard parallels 2°40' apart. This gives a maximum scale change of .03 per cent too small between standard parallels, and .07 per cent too large at 1°10' beyond either parallel. The older method using as standard parallels 7°-20°, 33°-45°, and 55°-65°, has a scale change of .55 per cent between standard parallels. Some standard series charts still exist on those old standard parallels but rapid conversion is in effect.

Some standard series charts, falling in the bands from 0° to 4° north and 0° to 4° south, were produced on the Mercator Projection. This condition is also being rectified to the new system of standard parallels to effect a better match between charts along the 4° parallels, sacrificing the match along the equator.

Comparison of Projections

The Lambert and Transverse Mercator projections are employed by the United States Geological Survey and the Army Map Service because: (1) of their mathematical simplicity (2) the scale factor at any point can be readily determined and (3) the limiting scale factor can be controlled by proper choice of zone width. On either of these systems, there is a unique relationship between grid coordinates and geographic coordinates, and the interchange between coordinates is relatively easy. Both projections are conformal. A polyconic projection for a single quadrangle map of 1 degree extent, or less, contains so little distortion that it may be considered a true representation of the earth's surface.

Contents of Maps

To civil defense planners, the most significant element of a map is its content. The purpose and use to which a map is put will depend to a large extent upon the content of a map. For example, if a civil defense planner desires to estimate the possible extent of fire damage that may result to a community from an atomic attack, it is essential the content of the map show the building density or fire susceptibility of the area being analyzed. A map showing this information can assist a planner in determining the probability of fire storm and conflagration areas.

Because individuals too often mistake the symbols as well as the types of descriptions shown for a subject matter on a map for its content, it is advisable, before classifying maps according to content, to explain the differences between these three. The content of a map consists of the subject matters presented. The aspects of the individual subject matters presented, such as the locations, shapes and sizes of areas of cities, are the types of descriptions. The graphic devices employed to visualize the types of descriptions are the symbols. The pictorial or geometrical designs -- line, circle, dot and so forth -- are graphic symbols; what they represent are the types of descriptions concerning the subject depicted.

The types of descriptions shown for a subject matter depend on the scale of the map and intent or purpose of a map. Some maps are abstracted and conventionalized to such a degree that only a single aspect of a subject matter is shown, as for instance, in a rainfall map.

The graphic devices employed depend on the scale of the map and the types of descriptions concerning the subject matters depicted. For example, on small scale maps, cities are usually shown by circles; on large scale maps, by their outlines. Although the locations of cities are shown on both the large and small scale maps, only on the large scale maps are the outlines also depicted.

Because a map tells a story simply and effectively, cartographers have developed techniques to show on a map the different types of descriptions for subject matters which pertain to what is under, on or over the surface of the earth. Maps, therefore, can be classified according to the subject matters they show for under, on or over the surface of the earth.

a. Maps showing subject matters under the surface -
    (1) Sub-surface - geological maps which show the areal and structural geology -- the science which treats of the history of the earth and its life, especially as recorded in rocks.
    (2) Bathometry - oceanographic maps which show depths by use of isobaths, tides, currents and so forth of waters.

b. Maps showing subject matter on the surface -
    (1) Maps showing different types of descriptions for relief, land water, vegetation and culture.

c. Maps showing subjects above the surface -
    (1) Maps showing different types of descriptions pertaining to weather and astronomy.

Maps Showing Sub-Surface Subject Matter

A description and explanation of the techniques employed to depict oceanographic and geological conditions are not furnished in this document since untrained people will find the reading of these maps difficult. Where civil defense planners consider these subjects may have an important bearing on their planning, they should obtain the services of specialists to analyze the information available and interpret their significance to civil defense.

Maps Showing Subject Matter on the Surface

a. Maps showing hydrography or water features usually show only the location, outline and size of water bodies such as: rivers, canals, dams, reservoirs, shore lines, lakes, streams, falls, rapids, swamps, and marshes. Specialized maps may show depths, currents, temperature and so forth.

b. Maps showing hypsography or relief features show only the surface configurations, such as: elevations, cliffs, sand dunes and a few others. Specialized maps may show the types of soil, erosion or slope of the land.

c. Maps showing vegetation and agriculture - vegetation maps usually show only the natural vegetation of an area; agricultural maps usually show the types of human cultivations, that is, the crops. In addition, specialized agricultural maps may show many other related important items such as: value of farm equipment, number of trucks, number of horses, farm tenancy, farm mortgages, value of farm property, average drained land, marginal lands and many others.

d. Maps showing the cultural or man-made features - Many maps contain little more than cultural features. The following list, showing types of maps available, indicates the different types of culture shown on maps:

(1) Locations Maps - A location map shows not only the outlines of an area in relation to larger, generally known regions, but also how the area fits into the main highways of communication and how it is related to river basins and physiographic divisions of a larger area.

(2) Political Maps - A political map shows the location of political areas but also political boundaries -- counties, townships, cities, states, state parks, national forests and the like. These maps also show the geographical names and often also indicate parallels and meridians. The elements of the location and political maps are often combined into one map.

(3) Land-Utilization Maps - A land utilization map links the environmental map with those of occupancy. On this type of map is usually shown the actual and possible uses of the land, including both agricultural and nonagricultural (industrial, urban, recreational, mining and lumbering) areas. Specialized maps will show the main types, such as forest, crop land and pasture land usually in great detail.

(4) Mineral Products and Mining Maps - These maps may show: (a) The areas where coal, oil, metals and other mineral products may be found (b) the production output of mineral products in a quantitative form (c) the number of employees employed (d) the money value of production which enable one to compare the importance of different mining districts (e) the locations of the minerals (mines, quarries, etc.) and the facilities and other similar types of information.

(5) Manufacturing Maps - These maps may show: (a) the locations of different types of industrial districts in relation to raw material, power, transportation and surface configuration (b) the locations of sources of raw materials and flow and distribution of manufactured products (c) the number of wage earners (d) the value of wages (e) the value of the products (f) value added by manufacturer and other related features.

(6) Transportation Maps - The four forms of transportation are air, rail, road and water. (1) Air - Air-Navigation charts or airways maps are either small or very large scale maps and show roads, railroads, rivers, cities, landmarks and altitudes. All information for flying, airports, radio beacons and signals are overprinted in red. Airway companies produce airway maps which indicate to passengers the routes. (2) Rail - Railway maps show the system of lines and sequence of stations. Sometimes, the region served is also shown. (3) Road - These maps show road conditions, cities, state parks, interesting places, elevations and so forth. (4) Water - These maps show routes, ports, and other related items of information.

(7) Recreation Maps - Types of information shown on these maps are: locations of parks, open public places, resorts, beaches, race tracks and places of scenic and historic interest.

(8) Social Conditions Maps - Types of conditions that may be shown are: health conditions, mortality, races, religions and education.

(9) Population Maps - Population maps show the densities or distributions of population.

(10) Air-Naval-Military Maps - These maps may show the locations of battlefields, airfields, army camps, installations, naval stations and other related data.

(11) Regional Economic Maps - These maps show for every region the characteristic products produced.

(12) Commodity Movement Maps - These maps show the production, transportation, and marketing of commodities, such as rubber, oil, cotton, wheat and so forth. This is usually shown by weight or thickness of a line.

TYPES OF GRAPHIC DESCRIPTIONS

The scale and purpose of a map determine, to a great extent, the number and types of graphic descriptions indicated on a map. Small scale maps, designed to present a general picture, usually indicate a limited number of subject matters and descriptions. They show such subject matters as civil divisions (states, counties, cities), roads, rivers, lakes, railroads and such descriptions as locations and boundaries. On large scale maps, such as city maps, however, the number of subjects and types of graphic descriptions shown are many and varied.

The following are some, but by no means all, of the various types of graphic descriptions found on different kinds of maps.

1. Spatial Position or Location - The location of a subject is usually shown graphically by indicating its physical position in relation to: (a) larger areas (b) regions (c) the main highways of communications and (d) river basins.

2. Shape or Configuration - The shape of a subject is usually shown graphically by indicating its outlines or boundaries.

3. Size - The size of subject is usually shown graphically by indicating one of the following: (a) the physical magnitude (b) the extent of area (c) the bulk (d) the character or status with reference to importance or (e) a conventional specified measurement, such as, dollar value.

4. Material - The substance or parts of which a subject is composed is usually shown graphically by indicating the one or more elements from which the subject is formed.

5. Length - The length of a subject is usually shown graphically by indicating the longest dimension extent from end to end.

6. Width - The width of a subject is usually shown graphically by indicating the dimension measured across from side to side or in a direction at right angles to the length.

7. Depth - The depth of a subject is usually shown graphically by indicating the perpendicular measurement downward from the surface.

8. Capacity - The capacity of a subject is usually shown graphically by indicating one of the following: (a) the power of receiving, containing or absorbing (b) the extent of

room or space and (c) the maximum output, as electric output.

9. Rate - The rate of a subject is usually shown graphically by indicating one of the following: (a) the quantity or degree of a thing measured per unit of something else, such as, rate of speed, birth rate and so forth (b) the amount of payment or charge based on some other amount, such as, rate of pay per week, rate of interest per year (c) a fixed charge or price fixed according to a scale or standard, such as, railroad rates.

10. Time - The time, or period set apart in some way, is usually shown graphically for a subject by indicating (a) year (b) season of year (c) month (d) day of week (e) day or night (f) hour of day.

11. Distance - Distance is usually shown graphically for a subject by indicating the spatial relation between two points in terms of miles, feet or meters.

12. Weight - The weight of a subject is usually shown graphically by indicating the specified amount in terms of dram, grain, ounce, pound, ton or other conventional specified measurement.

13. Source - The source of a subject is usually shown graphically by indicating its origin.

14. Intensity - The intensity of a subject is usually shown graphically by indicating the magnitude of energy per unit of surface, as for example, the intensity of radiation.

15. Use - The use of a subject is usually shown graphically by indicating its function.

16. User - The user of a subject is usually shown graphically by indicating the one who or that which uses the subject.

17. Coverage - Coverage is usually shown graphically by indicating the portion of a group or community reached by the particular subject.

18. Motion - Motion is usually shown graphically for a subject by indicating its movement, flow or change.

19. Process - Process is usually shown graphically for a subject by indicating its continuous change in time. If the process indicates a tendency in a specified or implied direction, then it is considered a trend.

20. Direction - The direction of a subject is usually shown graphically by indicating the line or course to which the subject is pointing.

21. Variability - The variability of a subject is usually shown graphically by indicating a change in its form, position, state or quality.

22. Elevation or Altitude - The elevation or altitude of a subject is usually shown graphically by indicating its height.

23. Distribution - The distribution of a subject is usually shown graphically by indicating the mode or manner it is spread out over an area. The primary purpose of indicating the distribution of a subject is to show its pattern or arrangement over an area since it often can suggest or reveal a design. The distribution may be of a subject that covers an area, such as a forest, or a subject that does not cover an area. Thus, there are two types of distribution: (a) areal and (b) non-areal. Areal distributions are of two kinds: (a) non-quantitative and (b) quantitative. The three types of non-quantitative areal distribution are: (a) simple (b) compound and (c) dominant.

Simple Areal Distribution - In this type of distribution, the areal distribution of a specific subject is shown without taking into account the density of distribution. Examples are: maps showing the distribution of forests, lakes, mountains, deserts, metropolitan areas, state capitals, cities and so forth in the United States.

Compound Areal Distribution - In this type of distribution, the areal distribution of a specific subject is shown as it is divided according to the various types of subdivisions. Examples are: maps showing the distribution of land use, soil, geology, building density, building construction and building heights.

Dominant Areal Distribution - In this type of distribution, the areal distribution of only the dominant type of a mixed subject is shown. Examples are: maps showing vegetation, language, religion and so forth.

Quantitative areal distributions show the variation in the value, amount or density of a subject.

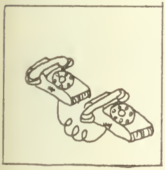
24. Identification - The identity of a subject is usually shown graphically by indicating its name.

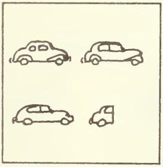
25. Density - The density of a subject is usually shown graphically by indicating the quantity per unit of volume or area.

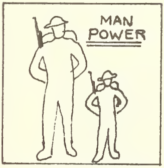
TECHNIQUES OF GRAPHIC PRESENTATION

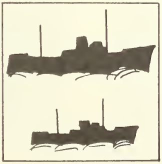
A graphic presentation is the employment of visual devices to delineate information clearly and vividly. On maps, the common visual devices used are: (a) drawings or sketches (b) symbols (c) lines (d) signs (e) pictograms (f) diagrams (g) numerals (h) letters (i) color. Factors influencing the employment of a particular visual device are: (a) the scale of the map (b) the subject (c) the type of description (d) the method of reproduction (e) the type of map -- planimetric, hypsometric, topographic, air mosaic. Since a knowledge of the techniques of graphic presentation -- the procedure essential to expertness of application of these devices -- will enhance an individual's understanding and ability to read maps, a description and discussion of each visual device is included in this section.

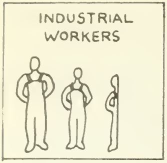
Drawing or Sketch -- In a drawing or sketch, a subject is represented by indicating an outline of its chief features. This device is usually employed on economic maps where figurettes are used to show quantities broken up into countable units. Examples of figurettes found on maps are: telephones, automobiles, persons, animals, ships, buildings and so forth. Drawings and sketches are used on pictorial types of maps. On these maps, the outlines of the land forms only the background for the pictures. Examples of types of figurettes employed on maps are:

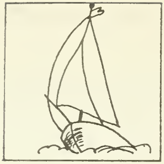




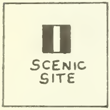


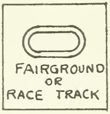


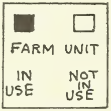


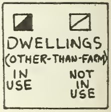


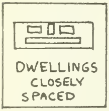
Symbols - A symbol is a graphic device which suggests something else by reason of relationship, association, or convention. It is a conventional device used instead of a word or words to represent subjects and types of graphic descriptions. Most map symbols look something like the actual thing they stand for. A good symbol is one which can be recognized without a legend. Most symbols are either reminiscent of the features they represent or have been sanctioned by centuries of use. The following show some common symbols found on maps:

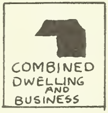


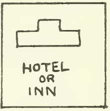


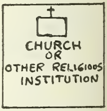


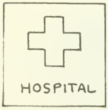


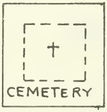


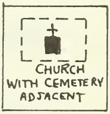


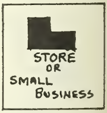


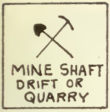


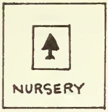


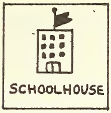


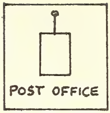


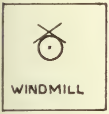


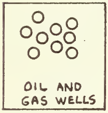


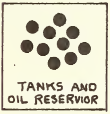


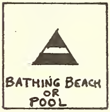




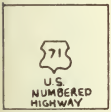


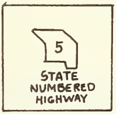


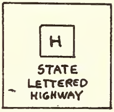




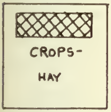
Signs -- A sign is a publicly displayed notice identifying something by name. Signs are frequently used on road maps. Often, the route number is shown within the sign. Examples of types of signs used on maps are:

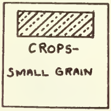


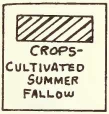


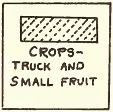


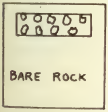
Designs -- On maps, designs consist of patterns. Patterns are used to delineate subject matter which is spread over areas. Examples of types of designs found on maps are:

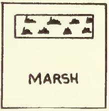


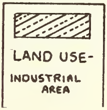


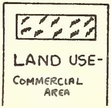


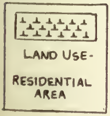






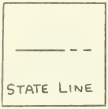


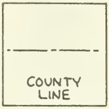


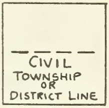


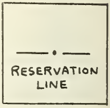
Lines -- Lines are employed on maps for delineating: (a) outlines of metropolitan areas or large cities (b) boundaries (states, counties, minor civil divisions, lakes, parks, cemeteries and so forth) (c) roads (d) rivers (e) railroads (f) tunnels (g) bridges (h) elevations (contour lines) (i) traffic patterns and other related subjects. Examples of types of lines employed on maps are:

BOUNDARIES

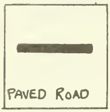


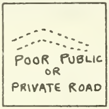


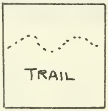


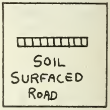


ROADS

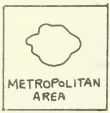


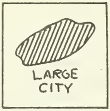


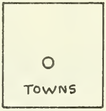


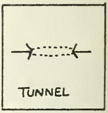


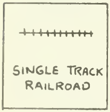
OUTLINE OF AREAS

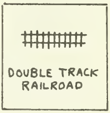


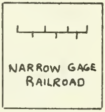


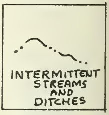


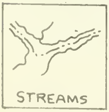


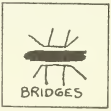


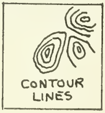


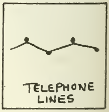




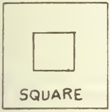


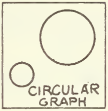


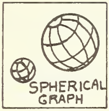


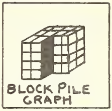


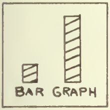
Pictograms -- Pictograms are used on maps to compare quantities and to represent statistical facts. Examples of types of pictograms found on maps are:

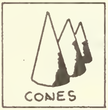


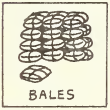


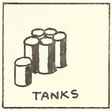




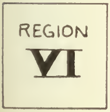


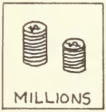


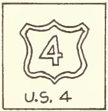


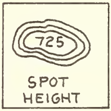


Numerals -- A numeral is a figure or character used to express a number. Numerals are used on maps for identification purposes, such as to identify a federal or state highway. Numerals are used, also, to indicate population size, dollar value, volume, distance of miles, elevations and so forth. Examples of numerals used on maps are:









Letters -- A letter is an alphabetical character. On maps, letters may be used for showing the location of products, minerals and so forth. The first letter of the name of the product, such as C for cotton, S for sugar, is shown on the map.

Abbreviations are often used on maps for identification purposes. Abbreviations should be used only when their meanings are unmistakeable and when they will serve a useful purpose.

Color -- Colors are used on maps to help identify terrain features. The colors usually found on maps are black, blue, brown, green and red.

Black - for works of man.
Blue - for water and swamps.
Brown - for contours, cuts and fills, and some cultivated fields on large-scale maps.
Green - for woods and other vegetation.
Red - for certain good roads.

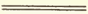
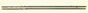
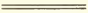
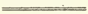
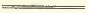
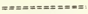
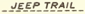
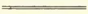
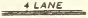
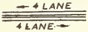
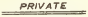
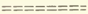
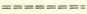
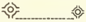
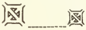
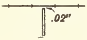
Map Symbols Shown on Topographic Maps (USGS and AMS)

A topographic map, as distinguished from other kinds, portrays by some means the shape and elevation of the terrain. United States Geological Survey topographic maps usually represent elevations and landforms - the shapes into which the earth's surface is sculptured by natural forces - by contour lines. Other features are shown by a variety of conventional signs, symbols, lines, and patterns, which are printed in appropriate colors and identified by names, labels, and numbers. The following pages indicate the features shown on topographic maps.

TOPOGRAPHIC SYMBOLS APPEARING ON UNITED STATES GEOLOGICAL SURVEY MAPS

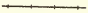
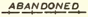
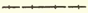
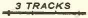
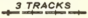
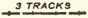
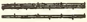
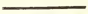
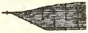
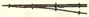
BLACK SYMBOLS

ROADS-HIGHWAYS

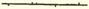
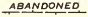
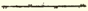
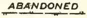
Class 1–Hard surface, heavy-duty, four or more lanes wide	
Class 2–Hard surface, heavy-duty, two or three lanes wide	
Class 3–Hard surface, medium-duty, four or more lanes wide	
Class 4–Hard surface, medium-duty, two or three lanes wide	
Class 5–Improved, light-duty	
Class 6–Unimproved dirt	
Class 7–Trails: important foot, bridle, pack, marked, and named trails	
Streets in urban areas including Class 1 and 3 roads	
Dual highway with dividing strip 25′ or less in width, 50′ at 1:40 000	
Dual highway with width of dividing strip exceeding 25′, 50′ at 1:40 000	
Private road	
Under construction–Classification known	
Under construction–Classification unknown	
Traffic circle	
Cloverleaf	
Dead end road	

RAILROADS

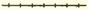
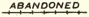
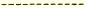
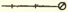
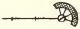
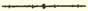
U. S. Standard Gage

Single track	
Single track abandoned	
Single track under construction	
Multiple main line track	
Multiple track abandoned	
Multiple track under construction	
Juxtaposition	
Railroad in street	
Yards	
Sidings	

Narrow Gage

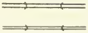
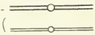
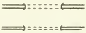
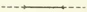
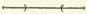
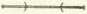
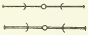
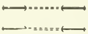
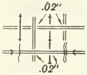
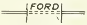
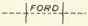
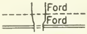
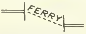
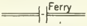
Single track	
Single track abandoned	
Multiple track	
Multiple track abandoned	

Miscellaneous

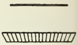
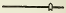
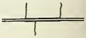
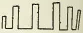
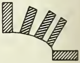
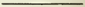
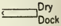
Carline	
Carline abandoned	
Dismantled railroad or carline	
Turntable	
Roundhouse and turntable	
Station	

BLACK SYMBOLS

BRIDGES-VIADUCTS-TUNNELS-CROSSINGS

Bridge: road	
Drawbridge: road	
Tunnel: road	
Footbridge	
Bridge: single track railroad	
Bridge: multiple track railroad	
Drawbridge: railroad	
Tunnel: railroad	
Underpass, overpass Bridge over stream, road, railroad	
Ford: road	
Ford: trail	
Ford: road or trail	
Ferry	
Ferry	

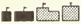
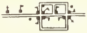
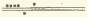
DAMS-PIERS-BREAKWATERS-ETC.

Important small masonry or earth dams	
Large masonry dam	
Dam with lock	
Dam carrying road	
Breakwater, jetty, pier, wharf	
Breakwater, pier, wharf, causeway	
Covered pier or wharf	
Seawall	
Canal lock or sluice gate	
Canal lock gate for double line stream	
Dry dock	

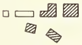
BLACK SYMBOLS

BUILDINGS

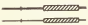
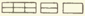
Class 1: Dwellings, place of employment, etc.

Small buildings	• • • • • • • • • • •
Small buildings in congested areas	• • • • • • • • • • • • • • •
Large buildings	■ ■ ▨ ▨
School	⚐
School in congested areas	⚐
Church	✝
Church in congested areas	✝
Large school or church	
School, college, etc.	
Temporarily abandoned school or church	⚐ *(Abandoned)*
School or church placement	
Building placement	

Class 2: Barns, greenhouses, grandstands, snowsheds, warehouses, etc.

Small buildings	▫ ▫ ▫ ▫ ▫ ▫ ▫ ▫ ▫ ▫
Large buildings	

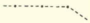
Miscellaneous structures

Snowshed	
Sewage disposal or filtration plant	
Masonry swimming pool, reservoir, or fish hatchery	▭
Covered reservoir	▨
Ruins	⬚ ⁛ ▫ Ruins
Cliff dwelling	

MINE SYMBOLS

Open pit mine, quarry, clay, or gravel pit	⚒ Gravel Pit
Mine tunnel entrance adit or cave	
Prospect	x
Mine shaft	▪

OTHER CULTURE SYMBOLS

Power transmission line	
Landmark lines: ski lift, incline railway, fence line, tramway, etc.	_ TRAMWAY _
Telephone or telegraph line	— — — — — —
Gas or oil pipe line underground	— — — — — —
Gas or oil pipe line above ground	———————
Walls	———————
Prominent wall	═══════
Wells (excluding water)	○ Gas Well
Wells (when numerous)	Oil Wells
Tanks: oil, gas, water, etc.	• ● ● Oil Tanks
Tanks: oil, gas, water, etc.	▨ ▨ Gas Tanks
Located or landmark object	○ Radio Tower
Windmill	⚲ Salt Well
Gaging station	⊗ Gaging Station
Pumping station	◦ Pumping Station

BLACK SYMBOLS

BOUNDARIES—In order of precedence.

National	——— – – ———
State or territory	——— – – ———
County, parish, municipio, judicial division	——— – ——— –
Civil township, town, district, precinct, barrio	—— —— —— ——
Incorporated city, village, town, borough, or hamlet	– – – – – – – –
National or state reservation, park, and monument	—— —— –
Small park, cemetery, airport, etc.	- - - - - - - - -
Land Grant	*On red drawing*
Township, range, and section	*On red drawing*

Miscellaneous boundary data

Boundary in road	━━━━━━
Approximate boundary	***Use normal symbolization. Label.***
Indefinite boundary	***Use normal symbolization at ½ specified line weight. Label***
Small cemetery	⸬ Cem † Grave
Cemetery	[†]
Cemetery	[Cem]

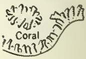
CONTROL DATA—MONUMENTS

Horizontal and vertical control station marked with tablet. Spirit level elev. third order or better	BM △ 1246
Horizontal and vertical station—any recoverable mark except a tablet. Spirit level elev. third order or better	△ 1146
Horizontal station with precise vertical angle elev. Marked with tablet	VABM △ 6785
Horizontal station with vertical angle or checked elev. Any recoverable mark including a tablet	△ *4578*

CONTROL DATA—MONUMENTS

Vertical control station marked with tablet. Spirit level elev., third order or better	BM × 1208
Vertical station—any recoverable mark other than tablet. Spirit level elevation third order or better	× 5628
Boundary monument marked with tablet. Spirit level elev., third order or better with or without geodetic position. Show land grant monument on red drawing	BM ▫ 6724
Boundary monument without tablet. Spirit level elev., third order or better with or without geodetic position. Show land grant monument on red drawing	▫ 1274
Checked spot elevation	× *5970*
Boundary monument with number and elevation	94 ▫ *628*
Reference monument	▫
U. S. mineral or location monument	▲
Land grant boundary monument	*On red drawing*
Horizontal control point coincident with section corner	—△—
Vertical control point coincident with found section corner	—+—
Other control points. Object may or may not have geodetic position	∘

FORESHORE-OFFSHORE FEATURES

Foreshore flat	Mud Sand
Rock or coral reef	
Small rock or coral reef	⁘ Coral Reef
Pile, dolphin, stump, or snag	∘ Pile Piles

BLACK SYMBOLS

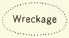
FORESHORE--OFFSHORE FEATURES (cont'd)

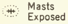
Rock bare or awash dangerous to navigation

Rock bare or awash

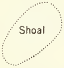
Group of rocks bare or awash

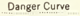
Exposed wreck

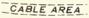
Exposed wreckage or foul ground


Masts exposed on sunken wreck


Sunken wreck

Shoal


Danger curve


Area limits


Sunken rock

(Soundings and depth curves shown on blue drawing)

MISCELLANEOUS

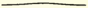
Oil sump or sludge pit

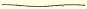
Open oil reservoir

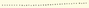
Drive-in theater

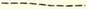
BROWN SYMBOLS

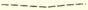
CONTOURS

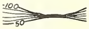
Index contour


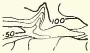
Intermediate contour


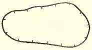
Supplementary contour


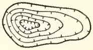
Approximate index contour


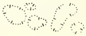
Approximate intermediate contour


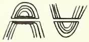
Feathering-out treatment


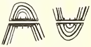
Carrying contour


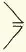
Depression contour


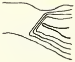
Adjacent depression contours


Supplementary depression contours


Cut


Fill: road or railroad


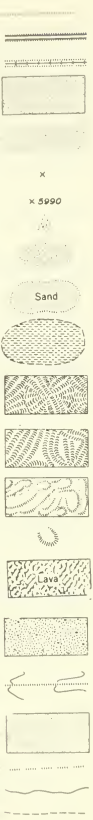
Contouring at ditches and canals


Large earth dam or levee


BROWN SYMBOLS

MISCELLANEOUS

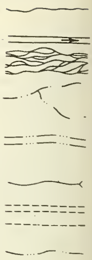
- Levee
- Levee with road–levee with railroad
- Sand areas, dunes
- Wash
- Spot elevation cross
- Unchecked spot elevation
- Glacial moraine
- Dry lake or pond
- Sand in open water area *
- Tailings pond
- Tailings
- Strip mine
- Strip mine, waste area
- Mine dump
- Distorted surface area *
- Gravel beach
- Contouring at levees
- Shifting sand dune area
- Spoil bank
- Shoreline
- Indefinite shore line



BLUE SYMBOLS

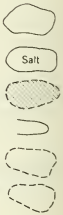
STREAMS

- Perennial stream
- Perennial stream
- Braided stream
- Intermittent stream
- Intermittent stream
- Stream disappearing at a definite point
- Unsurveyed perennial stream
- Wash



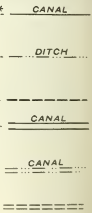
LAKES–PONDS

- Perennial lake or pond
- Perennial salt lake or pond *
- Intermittent lake or pond
- Reservoir natural shoreline
- Dry lake or pond
- Indefinite or unsurveyed shoreline



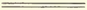
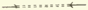
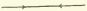
CANALS–AQUEDUCTS

- Canal, flume, or aqueduct *
- Intermittent drainage or irrigation ditch
- Abandoned canal, flume, or aqueduct
- Canal, flume, or aqueduct
- Intermittent drainage or irrigation canal
- Abandoned canal, flume, or aqueduct

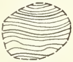
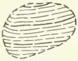
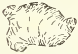
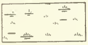
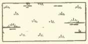
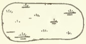
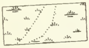
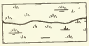
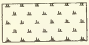
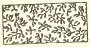
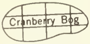
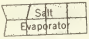
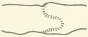


BLUE SYMBOLS

CANALS—AQUEDUCTS (cont'd)

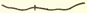
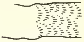
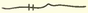
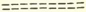
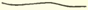
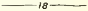
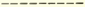
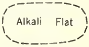
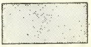
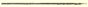
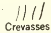
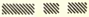
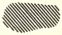
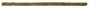
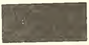
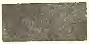
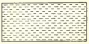
Navigable canal	
Underground flume, penstock, aqueduct, or similar feature	AQUEDUCT
Aqueduct tunnel	
Elevated aqueduct, conduit, etc.	

MISCELLANEOUS

Water well *	o Well
Spring	
Glacier or permanent snow field	
Glacier approximate contours	
Glacier or permanent snow field	
Marsh or swamp	
Wooded marsh or swamp	
Submerged marsh or swamp	
Marsh or swamp outline	
Show stream in marsh or swamp when channel exists	
Rice field	
Mangrove	
Cranberry bog *	 Cranberry Bog
Salt evaporator *	 Salt Evaporator
Large falls	

BLUE SYMBOLS

MISCELLANEOUS (cont'd)

Small falls	
Large rapids	
Small rapids	
Channel in water area	
Permanent channel in wash	
Depth curve	 18
Land subject to inundation	
Water surface elevations	764
Alkali flat	 Alkali Flat
Water area	
Perennial drainage or irrigation ditch	
Glacial crevasses	 Crevasses
Soundings	75
Sewage disposal or filtration plant	
Masonry swimming pool, reservoir, or fish hatchery	
Intermittent lake or pond	
Canal or stream	
Water area	
Submerged marsh or swamp	
Covered reservoir (water)	
Land subject to inundation	

RED SYMBOLS

UNITED STATES LAND SURVEYS

Land grant or mining claim .... — — —
Land grant monument with or without geodetic position .... ▫
Township or range line .... ———
Township or range line: location doubtful .... — — — — —
Section line .... ———
Section line: location doubtful .... — — — — —
Section corners:
Found cor.– Indicated cor. .... + +
Closing corners:
Found cor.– Indicated cor. .... ┬ ┬

OTHER LAND SURVEYS

Township or range line .... ····················
Section line .... ·
Section corner ···· + ····
Closing corner ···· ┬ ····

ROAD DATA

Class 1 road .... ━━━
Class 2 road .... ———
Class 3 road .... ━ ━ ━
Class 4 road .... — — —
Change in number of lanes ....
Direction arrow .... → ↷ ↶
Route markers 150 230

RED SYMBOLS

MISCELLANEOUS

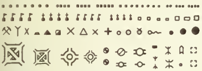
Urban area .... ▨
National park boundary .... ▨

GREEN SYMBOLS

Woods, brushwood .... ■
Orchard .... ▦
Vineyard .... ☰
Scrub .... ▒
Wooded marsh or swamp .... ■
Mangrove .... ■

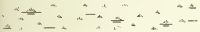
STICK UP PATTERNS AND LINE CUTS

USGS 1 *Culture symbols*



USGS 1A *For use on 1:31 680*

USGS 2 *Marsh*



USGS Contour Numbers (opaque)

1–Numbers *100 – 5990*

2–Numbers *6000 – 12690*

For 1 to 1 reproduction

3–Numbers *10 – 14500*

USGS Spot elevations

4A–Numbers *0 – 2000*

4B–Numbers *2000 – 4000*

4C–Numbers *4001 – 6000*

4D–Numbers *6000 – 8000*

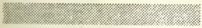
4E–Numbers *8001 – 10000*

4J–Numbers *5239 – 5998*

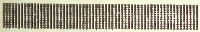
4K–Numbers *5995 – 6683*

USGS 5 (Zip-A-Tone 2)
House omission and open water areas

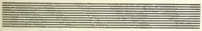
USGS 6 (Zip-A-Tone 5A)
Fill for large Class 1 buildings



USGS 7 *Vineyard*



USGS 8 (Zip-A-Tone 66)
Fill for sewage disposal, filtration plant, intermittent lakes, large Class 2 buildings



USGS 8B
Fill for intermittent pond when no blue tint drawing

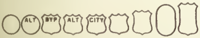
USGS 9 *U S highway markers*

225 *Nos. 1 to 830 (not consecutive)*

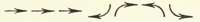
USGS 9A *State highway markers*

(225) *Nos. 1 to 309*

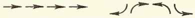
USGS 10 *Misc highway markers and Nos. 1 to 1000*



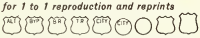
USGS 11 *Highway direction arrows*



USGS 11A *Highway direction arrows for 1 to 1 reproduction and reprints*



USGS 12A *Alternate route markers for 1 to 1 reproduction and reprints*



USGS 13A-1 *Road legend for 1 to 1 reproduction of 1:24 000 1:31 680 and 1:62 500*

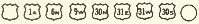
USGS 13 B-1 *Road legend*

USGS 14 *Declination diagram*

USGS 15–16 *Highway markers and numbers for 1 to 1 reproduction*

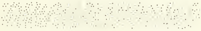
(275) *Nos. 1 to 1000* *Numbers* 1 to 876

275 *Nos. 1 to 830 (not consecutive)*

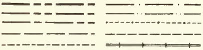


USGS 17
Sand, dry lakes.

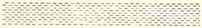
USGS 17A *Undulating sand areas*



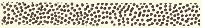
USGS 18
Boundaries for national, state, county, township, city, reservation, and grant. Transmission line, landmark line and double tract RR.



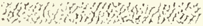
USGS 19 *Land subject to inundation Tailings pond*



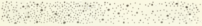
USGS 20 *Scrub*



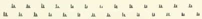
USGS 21 (Stic-Pat AMS 189)
Distorted surface area-i.e. lava etc.



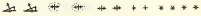
USGS 22 (Stic-Pat AMS 188)
Gravel beach and glacial moraine



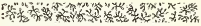
USGS 23 (Stic-Pat AMS 116)
Rice field



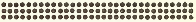
USGS 24 *Hazards to navigation*



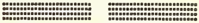
USGS 25 (Stic-Pat AMS 108)
Mangrove



USGS 26–1 *Orchard*

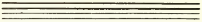


USGS 27 (VT-10) *Buildings*

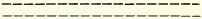


USGS 28-28A
Registration tick stick-up

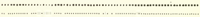
USGS 29
U S land survey lines



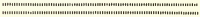
USGS 30 *Township and section lines, location doubtful*



USGS 31
Other land survey lines



USGS 32 *Levee*



USGS 33 *National park boundaries*

USGS 33–1 *National park boundaries*

USGS 34 *State location diagrams for all states*

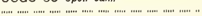
USGS 34–1 *State location diagrams for Atlantic Region*

USGS 34–2 *State location diagrams for Central Region*

USGS 34–3 *State location diagrams for Rocky Mountain Region*

USGS 34–4 *State location diagrams for Pacific Region*

USGS 35 *Spoil bank*



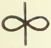
Civil Defense Map Symbols

Due to an increased use of maps for urban analysis purposes, plotting operational information, delineating dispersal routes and performing map studies and problems, the standardization of map symbols, specially adapted to Civil Defense use, has assumed an ever greater importance. The map symbols, depicted herein, have been designed for use on maps in addition to the general topographic symbols commonly found on existing governmental and commercial maps. Symbols other than those shown herein may be used on Civil Defense maps but care should be exercised to assure that they do not conflict with existing symbols and are explained in an accompanying legend.

The symbols do not conform to any scale, and should vary in size with the size of the individual map on which they are imposed. Their size and position should not confuse nor obliterate adjacent symbols or other map data. All map symbols have been designed so that they can be used without regard to color, and are susceptible of easy and rapid reproduction by unskilled personnel; strict adherence to the minutia of their detail and proportion is neither required nor to be expected in copying them.

— MAP SYMBOLS —

AVIATION


1. Emergency landing field

2. Ground observer post

3. Flight strip

4. Filter center

COMMAND

1. Control center (city or county)

2. Alternate control center

3. Zone headquarters

4. Sector headquarters

5. Aid check point (insert numerical designation in triangle)

6. Plant protection unit

COMMUNICATIONS

1. Radio station

2. Commercial telephone central office

3. Portable telephone switchboard

ENGINEERING AND PUBLIC WORKS

1. Water tank

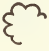
2. Assembly point

3. Equipment

4. Engineering and public works headquarters

5. Sewage disposal plant

FIRE


1. Fire area

2. Fire storm

3. Fire line

4. Fire house

5. Fire headquarters

FOOD DISTRIBUTION

1. Food distribution depot

2. Milk pasteurization plant

3. Wholesale bakery

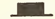
4. Wholesale grocery or chain store warehouse

5. Wholesale meat packer and distributor

6. Other food processor or wholesale distributor (Specify)

GEOGRAPHIC

1. Ground zero


2. Shelter (surface)

3. Shelter (underground)

MEDICAL

1. Permanent hospital

2. Improvised emergency hospital

3. First aid station

4. Holding station

5. Secondary aid station

6. Supply and assignment depot

7. Mortuary

8. Burial ground

– MAP SYMBOLS –

POLICE

1. Police station

2. Police headquarters

PRESS-RADIO

1. Press-radio headquarters

RADIOLOGICAL

1. Radioactive hazard

2. Radiological monitor

3. Radiological team

RESCUE

1. Rescue team

SUPPLY

1. Emergency distribution point (C—coal; O—oil; G—gasoline; P—Petroleum products)

2. Emergency supply depot

TRAFFIC

1. Street (or bridge) block

L M R

2. Local mobilization road

⟶

3. One-way traffic

⟷

4. Two-way traffic

←ALT→

5. Alternate traffic

6. Peripheral road

7. By-pass

TRANSPORTATION

1. Motor repair shop

2. Motor transportation pool

3. Filling station

WARDEN

1. Warden zone headquarters

2. Warden district headquarters

3. Warden post headquarters

–D–D–

4. Warden district boundaries

–P–P–

5. Warden post boundaries

WELFARE

1. Welfare

2. Welfare center

3. Assembly center

4. Reception center

5. Central registration bureau

6. Outdoor welfare area

7. Central defense emergency aid bureau

8. Mobile welfare team

9. Collecting point

10. C. D. workers' rest center

CENSUS TRACT AND ENUMERATION DISTRICT MAPS

Census tract and enumeration district maps define areas for which census information is available. Consequently they are the most practicable for plotting population statistics. They are especially well suited for the preparation of estimates of possible A-bomb casualties. For most purposes census tract maps, because they are readily available, cheaper, and simpler to use, are preferable to enumeration district maps.

Census tracts are areas of varying size and shape, each containing approximately 5,000 residents, although some may contain only a few people, or none at all. Single tracts in a few of the larger cities may contain more than 300,000 people. Maps of these tracts have been prepared for most large and medium-sized cities, and copies are available in the municipalities concerned. Figures for resident population by census tracts together with related information are available in Bureau of the Census bulletins.

Enumeration districts are relatively small units which comprise the tracts and contain approximately 800 people. The districts vary considerably in area; one may consist of part of a single building whereas another may include 50 blocks or more. Maps of enumeration districts have been prepared by the Census Bureau for all United States cities and these may be used where census tract maps and figures cannot be obtained. Enumeration district maps are not available for general distribution. However, a few cities have these maps, and maps for other cities may be ordered from the Census Bureau at a cost of approximately $100 per 500,000 population. As an alternate possibility, descriptions of enumeration district boundaries for various cities may be obtained from the Burea at moderate cost.

Population figures for enumeration districts may be obtained from the Bureau on special order. Approximate costs are as follows:

(a) To hand copy population totals; $25 per 500,000 population.

(b) To photostat population totals: $15 per 500,000. (These are less convenient to use than hand copy.)

(c) To photostat entire tabulation; $250 per 500,000.

(d) To prepare a breakdown by age groups, sex, or other characteristics; as much as $10,000 for a large city.

UNITED STATES GEOLOGICAL SURVEY MAPS

Types of Quadrangles Published

The Geological Survey issues standard topographic maps covering the United States, Alaska, Hawaii and Puerto Rico. Under the general plan adopted, the unit of survey is a quadrangle bounded by parallels of latitude and meridians of longitude.

a. Quadrangles covering 7 1/2 minutes of latitude and longitude are generally published at the scale of either 1:24,000 (1 inch = 2,000 feet) or 1:31,680 (1 inch = 2,640 feet or 1/2 mile).
b. Quadrangles covering 15 minutes of latitude and longitude are published at the scale of 1:62,500 (1 inch = approximately 1 mile).
c. Quadrangles covering 30 minutes of latitude and longitude are published at the scale of 1:125,000 (1 inch = approximately 2 miles).

For certain portions of the United States, quadrangles representing one degree (60 minutes) of latitude and two degrees of longitude have been published at the scale of 1:250,000 (1 inch = approximately 4 miles).

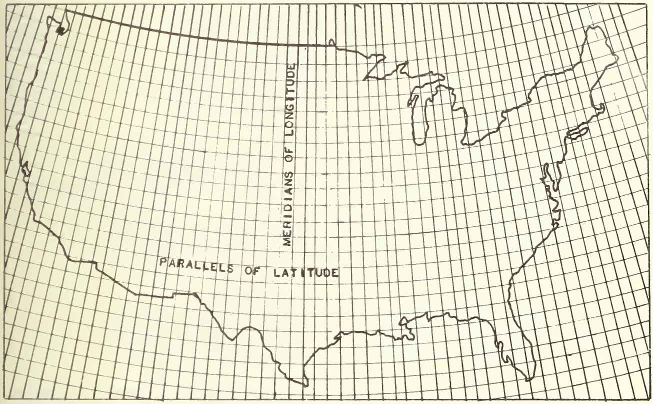
Quadrangles for the entire United States representing two degrees of latitude and six degrees of longitude at the scale of 1:500,000 (1 inch = approximately 8 miles) are also available.

Titles of Quadrangles

Each quadrangle is designated by the name of a city, town or prominent natural feature within it. On the margin of the maps is printed the names of adjoining quadrangle maps that have been published.

Meridians of Longitude and Parallels of Latitude

The illustration below visually depicts for a map projection which lines are referred to as "parallels of latitude" and "meridians of longitude". The parallels of latitude are the horizontal lines and extend from East to West or West to East. The meridans of longitude are the vertical lines and extend from the North to the South or the South to the North.



USGS Release - "Topographic Map Symbol Sheet"

The Department of Interior, USGS release titled, "Topographic Map Symbol Sheet", dated May, 1955, a reprint of which will be found on pages 7.3, furnishes additional descriptive material concerning the quadrangle map series and instructions for obtaining quadrangle maps.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TOPOGRAPHIC
MAP SYMBOL SHEET
MAY 1955

QUADRANGLE MAPS, AND QUADRANGLE MAP SERIES

Quadrangle maps cover four-sided areas bounded by parallels of latitude and meridians of longitude. Quadrangle size is given in minutes or degrees. The usual dimensions of quadrangles are: 7.5 by 7.5 minutes, 15 by 15 minutes, 30 by 30 minutes, and 1 degree by 1, 2, or 3 degrees.

Quadrangle map series are map groups of the same size quadrangles. In each series the maps follow a systematic quadrangle pattern, they have a uniform format, and they usually have the same scale.

MAP SCALE DEPENDS ON QUADRANGLE SIZE

The scale of a map is the ratio between a map distance and the same distance measured on the ground.

Map scale is given as a numerical ratio, and by bars marked in feet, meters, and miles.

STANDARD SCALES AND PRICES OF THE NATIONAL TOPOGRAPHIC MAP SERIES

SERIES	SCALE		PRICE
7.5 Minute	1:24,000	1 inch equals 2,000 feet	$0.20
7.5 Minute	1:31,680	1 inch equals one half mile	.20
15 Minute	1:62,500	1 inch equals about 1 mile	.20
1:63,360 (Alaska)	1:63,360	1 inch equals one mile	.20
30 Minute	1:125,000	1 inch equals about two miles	.20
1:250,000	1:250,000	1 inch equals about four miles	.50
1:250,000 (Alaska reconnaissance)	1:250,000	1 inch equals about four miles	.25

CONTOURS SHOW LAND SHAPES AND ELEVATION

The shape of the land, portrayed by contours, is the distinctive characteristic of topographic maps.

Contours are imaginary lines following the ground surface at a constant elevation above sea level.

The contour interval is the regular elevation difference separating adjacent contour lines on maps.

Contour intervals depend on ground slope and map scale; they vary from 5 to 200 feet. Small contour intervals are used for flat terrain; larger intervals for rugged mountain areas.

Supplementary dashed or dotted contours, at less than the regular interval, are used in flat areas.

Index contours, every fourth or fifth line, are heavier than others, and have elevation figures.

Hachures, form lines, and symbol patterns are also used to show some kinds of topographic forms.

Relief shading, an overprint giving a three-dimensional effect, is used on some quadrangle maps.

COLORS DISTINGUISH CLASSES OF MAP FEATURES

Black is used for man-made or cultural features, such as roads, buildings, names, and boundaries.

Blue is used for water or hydrographic features, such as lakes, rivers, canals, and glaciers.

Brown is used for relief or hypsographic features—land shapes portrayed by contours or hachures.

Green is used for woodland cover, with typical patterns to show scrub, vineyards, or orchards.

Red emphasizes important roads, shows built-up urban areas, and public-land subdivision lines.

STATE INDEX CIRCULARS SHOW MAPS PUBLISHED

For each State, and for Alaska, Hawaii, and Puerto Rico index circulars show all maps distributed. Index maps give quadrangle location, survey date, name, and publisher (if not Geological Survey). Listed also are: special maps and sheets with prices, map agents and federal distribution centers, addresses of map reference libraries, and detailed instructions for ordering topographic maps.

HOW MAPS MAY BE OBTAINED

Mail orders for maps west of the Mississippi River should be addressed to the Geological Survey, Distribution Section, Federal Center, Denver, Colo., and for maps east of the Mississippi River to the Geological Survey, Distribution Section, Washington 25, D. C. Maps of Alaska may also be ordered from the Geological Survey, 520 Illinois Street, Fairbanks, Alaska. Order by map name, State, and series. Maps without woodland overprint are furnished on request. A 20% discount is allowed on orders amounting to $10 or more. Each order for maps should be accompanied by exact payment in cash, or by money order or personal check made payable to the Geological Survey.

Sales counters are maintained in the following Geological Survey offices where maps of the area may be purchased in person: Room 1028, General Services Administration Building, Washington 25, D. C.; 2520 Marconi Avenue, Sacramento, Calif.; Room 468, New Customhouse, Denver, Colo.; Room 504, Federal Building, Salt Lake City, Utah; Room 529, Post Office Building, Los Angeles, Calif.; Room 724, Appraisers Building, San Francisco, Calif.; Room 210, Glover Building, Anchorage, Alaska; Room 117, Federal and Territorial Building, Juneau, Alaska; and Wright Building, Palmer, Alaska.

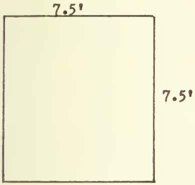
State index circulars and a folder describing topographic maps are furnished free on request.

Private agents sell quadrangle maps at their own prices. Names and addresses of private agents are listed in the State index circulars.

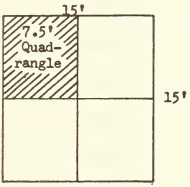
Schematic Illustration of the Area Covered by each Quadrangle Map Series

A schematic illustration showing how each quadrangle map series is related to the general quadrangle plan adopted by the USGS will be found below.

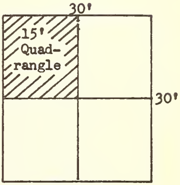
The scale for each quadrangle map series is given as a numerical ratio. Example: 1:24,000 or 1:62,500 and so forth. Pages 2.8 and 2.9 depict the areas covered by each quadrangle series.



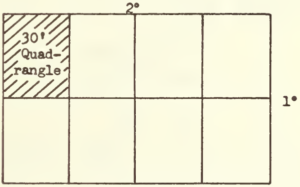
1:24,000 or 1:31,680 Scale



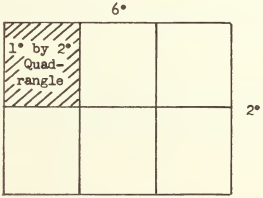
1:62,500 Scale



1:125,000 Scale



1:250,000 Scale



1:500,000 Scale

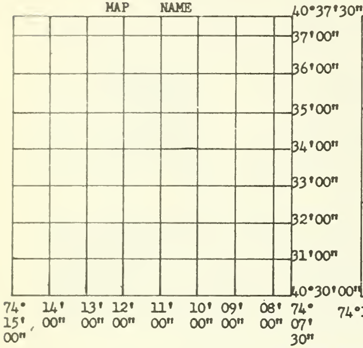
" = seconds
' = minutes
° = degrees

60" = 1'
60' = 1°

Schematic Illustrations
of
Area Covered by USGS Quadrangles

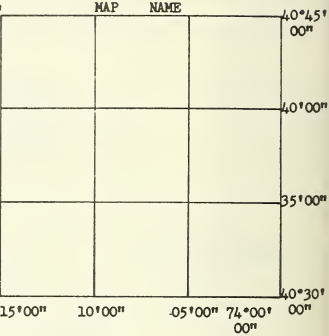
7.5 MINUTE SERIES

1:24,000 or 1:31,680 Scale



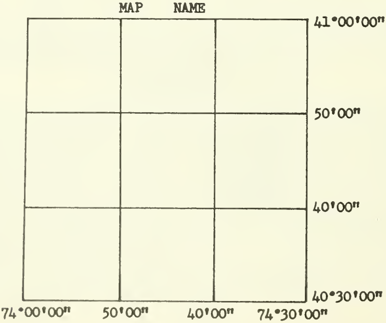
15 MINUTE SERIES

1:62,500 Scale



30 MINUTE SERIES

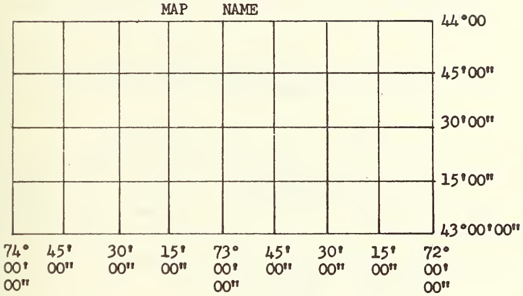
1:125,000 Scale



Schematic Illustrations of Area Covered by USGS Quadrangles

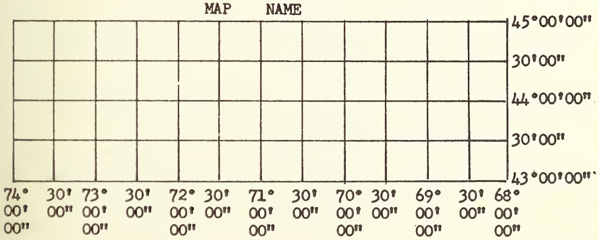
1°N-S x 2°E-W SERIES

1:250,000 Scale



2°N-S x 6°E-W SERIES

1:500,000 Scale



Scales of Quadrangle Map Series

The table below furnishes for each quadrangle map series the following:

a. the scale - in form of a numerical ratio
b. the minutes or degrees of latitude and longitude represented on the maps
c. the mileage distances of the minutes or degrees represented on the maps
d. the number of inches on the maps that are equivalent to one mile
e. the number of miles that one inch on the maps represent

UNITED STATES GEOLOGICAL SURVEY (USGS) MAPS

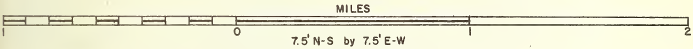
Scales of Quadrangle Map Series

Scale	Quadrangle Size		1 Mile Equals	1 Inch Equals
	Latitude	Longitude		
1:24,000	7.5 Minutes approx. 8.4 miles	7.5 Minutes approx. 6.8 miles	2.6 inches	0.38 mile
1:31,680	7.5 Minutes approx. 8.4 miles	7.5 Minutes approx. 6.8 miles	2.0 inches	1.5 miles
1:62,500	15 Minutes approx. 16.8 miles	15 Minutes approx. 13.6 miles	approx 1 inch	approx 1 mile
1:125,000	30 Minutes approx. 33.6 miles	30 Minutes approx. 27.2 miles	0.5 inch	2.0 miles
1:250,000	1 Degree approx. 67.2 miles	2 Degrees approx. 108.8 miles	0.25 inch	4.0 miles
1:500,000	2 Degrees approx. 134.4 miles	6 Degrees approx. 326.4 miles	0.125 inch	8.0 miles

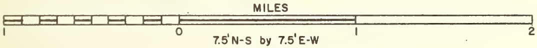
Below are the scales for each quadrangle map series in graphic form - by bars marked in miles.

BAR SCALES

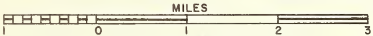
UNITED STATES GEOLOGICAL SURVEY QUADRANGLES



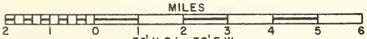
7.5' N-S by 7.5' E-W
(1:24,000 Scale)



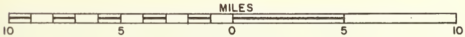
7.5' N-S by 7.5' E-W
(1:31,680 Scale)



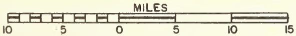
15' N-S by 15' E-W
(1:62,500 Scale)



30' N-S by 30' E-W
(1:125,000 Scale)



1° N-S by 2° E-W
(1:250,000 Scale)



2° N-S by 6° E-W
(1:500,000 Scale)

Selecting the Appropriate Quadrangle Map Series:

Scale 1:24,000 or 1:31,680 - 7.5' N-S by 7.5' E-W quadrangle map

This series should be used where detailed information for an urbanized area - city and its urban fringes - is desired. Quadrangles in this series show:

- a. the street pattern and names of the more important streets and highways
- b. the location of different types of buildings - dwellings, schools, churches, industrial plants and others
- c. railroads, railroad yards, roundhouses, and so forth
- d. bridges
- e. boundaries of political subdivisions
- f. water features - lakes, rivers, canals
- g. contours - imaginary lines following the ground surface at a constant elevation above sea level
- h. woodland cover
- i. airfields
- j. military areas
- k. port facilities
- l. other significant features

For the appropriate quadrangle to order, State Index Circulars, showing maps published, can be obtained from:

The United States Geological Survey
Distribution Section
Washington 25, D. C.

The circulars are index maps showing quadrangle location, survey date, name and published (if not Geological Survey). (see USGS release, "Topographic Map Symbol Sheet", Page B-19).

Scale 1: 62.500 - 15' N-S by 15" E-W quadrangle map series

This series should be ordered where detailed information for rural areas is desired. Quadrangles in this series cover more land area than shown on the 7.5 minute quadrangle series. Although the street patterns of urbanized areas are shown, street names and details are usually not indicated. These maps should be used for support planning purposes.

Scale 1:125,000 - 30' N-S by 30' E-W quadrangle map series

Although this series is useful in relation to determining the location of the major highways, the paucity of information indicated on the quadrangles limit their value in civil defense planning. A list of the quadrangles available for some of the principal cities will be found in Appendices B thru J.

Scale 1:250,000 - 1 N-S by 2 E-W quadrangle map series

These quadrangles show large built-up areas in yellow with no details except for the location of some of the major highways. The highway distribution system beyond urbanized areas, however, is indicated as well as the locations of small populated places, airports, military areas, woodlands, and other topographic features. Because each quadrangle covers an extensive area (approximately 68 miles by 108 miles), this series is useful for:

a. delineating the "aiming areas" and bands of A-B-C-D-damage for target areas
b. estimating the probable areas that may be subject to damage - blast, thermal and fallout - if one or more thermonuclear weapons were detonated
c. movement studies
d. reception and care studies
e. other studies relative to support planning.

The names of the quadrangles for each Region and each State within each Region will be found in Appendices B thru J.

Scale 1:500,000 - 2° N-S by 6° E-W quadrangle map series

These quadrangles, except for scale, show approximately the same type of information as the 1:250,000 scale maps. Each quadrangle, however, covers an area approximately 138 by 325 miles. This series is excellent for plotting "aiming area" information and for determining areas that may be subject to fallout.

The names of the quadrangles for each Region and for each State within each Region will be found in Appendices B thru J.

Scale 1:500,000 - State Base Maps

This series should be used where a small scale map for a State is desired. The maps show: a. the county boundaries b. water features c. locations and names of cities, towns and villages.

The State Base Maps will be found useful for plotting "aiming area" information and for determining areas that may be subject to fallout.

Special Maps: Scale 1:24,000 - Urban (Single Sheet) Maps

This series of special maps is being developed by the Geological Survey for urban areas. The maps will show the same information as the 7.5 by 7.5 minute quadrangle map series except that the universal transverse mercator grid system is being indicated on the margins of the maps by tick marks. The maps will be published both in mono-color (black and white) and multi-color. The mono-color series will not show the contours or elevations. The multi-color series will indicate the contours by brown lines and the extent of the built-up urban areas in red.

ARMY MAP SERVICE MAPS

The Army Map Service (AMS), Corps of Engineers, U.S. Army, publishes for military use only, quadrangle maps similar to the series issued by the USGS. In preparing the quadrangles, the Army Map Service utilizes the original data compiled by the USGS, as well as other sources. However, the AMS quadrangle map series differ from the USGS series. The principal difference between the AMS and USGS quadrangles are in the following areas:

a. Map projection
b. Scale
c. Universal Transverse Mercator Grid
d. Military information indicated

A comparison of map scales, projections and grids of the USGS and AMS quadrangle map series will be found in Chapters II and III.

Since AMS maps contain military information, for obvious reasons these maps are not published for civilian distribution. State and local civil defense organizations, therefore, cannot purchase these maps. OCDM Regions, however, can purchase the AMS quadrangles by writing direct to:

Commanding Officer
U.S. Army Map Service
6500 Brooks Lane
Washington 25, D. C.

The Army Map Service publishes a U.S. Map Catalogue which consists of a series of index maps for the United States and each State which show for each quadrangle map series the quadrangle location, sheet name and number and other pertinent data for ordering maps.

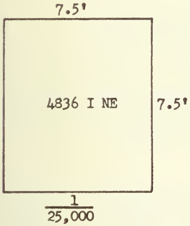
Comparison of USGS and AMS Quadrangles

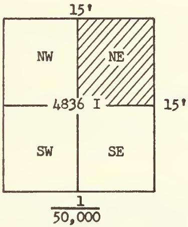
United States Geological Survey	Quadrangle Map Series	Army Map Series
Scale: 1:500,000 Projection: Lambert Conformal Conic Grid: None shown	2° N-S x 6° E-W	Scale: 1:500,000 Projection: Lambert Conformal Conic Grid: 10,000 meter UTM grid (printed in purple)
Scale: 1:250,000 Projection: Transverse Mercator Grid: 10,000 meter UTM grid with 10,000 yard U. S. Polyconic grid as secondary on some sheets *	1° N-S x 2° E-W	Scale: 1:250,000 Projection: Transverse Mercator Grid: 10,000 meter UTM grid with 10,000 yard U. S. polyconic grid as secondary on some sheets.
Scale: 1:125,000 Projection: Polyconic Grid: 10,000 yard U. S. Polyconic grid	30' N-S x 30' E-W	Scale: 1:100,000 Projection: Transverse Mercator Grid: 10,000 meter UTM grid with 10,000 yard U. S. polyconic grid as secondary on some of the colored sheets
Scale: 1:62,500 Projection: Polyconic Grid: None	15' N-S x 15' E-W	Scale: 1:50,000 Projection: Transverse Mercator Grid: 1,000 meter UTM grid
Scale: 1:24,000 or 1:31,680 Projection: Polyconic Grid: 10,000 foot grid shown on some sheets	7.5' N-S x 7.5 E-W	Scale: 1:25,000 Projection: Transverse Mercator Grid: 1,000 meter UTM grid; 1,000 yard U. S. Polyconic grid as secondary on majority of sheets.

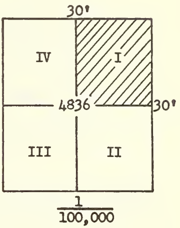
* Series is produced by AMS but published and distributed for civilian use by USGS.

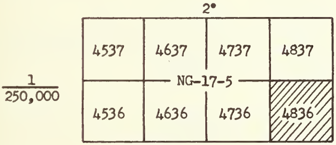
Schematic Illustration of the Area Covered by each Quadrangle Map Series

A schematic illustration showing how each quadrangle map is related to the general quadrangle plan adopted by AMS and the sheet numbering scheme will be found below.

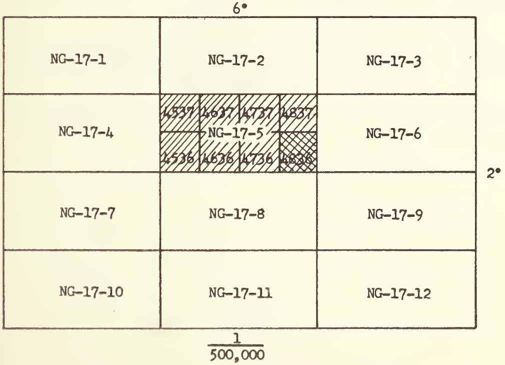








" = seconds
' = minutes
° = degrees
60" = 1'
60' = 1°



Scales of Quadrangle Map Series

The table below furnishes for each quadrangle map series the following:

a. the scale - in the form of a numerical ratio

b. the minutes or degrees of latitude and longitude represented on the maps

c. the mileage distances of the minutes or degrees represented on the maps

d. the number of inches on the maps that are equivalent to one mile

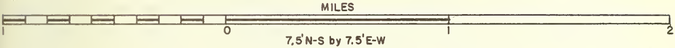
e. the number of miles that one inch on the maps represent

SCALE	QUADRANGLE SIZE		1 MILE EQUALS	1 INCH EQUALS
	LATITUDE	LONGITUDE		
1:25,000	7.5 minutes Approx. 8.4 miles	7.5 minutes Approx. 6.8 miles	0.4 inches	2.5 mile
1:50,000	15 minutes Approx. 16.8 miles	15 minutes Approx. 13.6 miles	0.8 inches	1.25 mile
1:100,000	30 minutes Approx. 33.6 miles	30 minutes Approx. 27.2 miles	1.6 inch	0.625 miles
1:250,000	1 degree Approx. 67.2 miles	2 degrees Approx. 108.8 miles	0.25 inch	4.0 miles
1:500,000	2 degrees Approx. 134.4 miles	6 degrees Approx. 326.4 miles	0.125 inch	8.0 miles

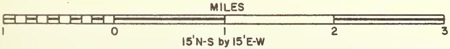
Below are scales for each Quadrangle Map Series in graphic form - by bars marked in miles.

BAR SCALES

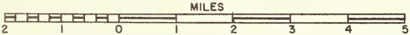
ARMY MAP SERVICE QUADRANGLES



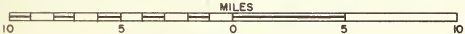
7.5'N-S by 7.5'E-W
(1:25,000 Scale)



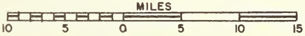
15'N-S by 15'E-W
(1:50,000 Scale)



30'N-S by 30'E-W
(1:100,000 Scale)



1° N-S by 2° E-W
(1:250,000 Scale)



2° N-S by 6° E-W
(1:500,000 Scale)

Scales of Quadrangle Map Series

The table below furnishes for each quadrangle map series the following:

a. the scale - in the form of a numerical ratio

b. the minutes or degrees of latitude and longitude represented on the maps

c. the mileage distances of the minutes or degrees represented on the maps

d. the number of inches on the maps that are equivalent to one mile

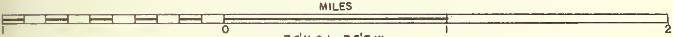
e. the number of miles that one inch on the maps represent

SCALE	QUADRANGLE SIZE		1 MILE EQUALS	1 INCH EQUALS
	LATITUDE	LONGITUDE		
1:25,000	7.5 minutes Approx. 8.4 miles	7.5 minutes Approx. 6.8 miles	0.4 inches	2.5 mile
1:50,000	15 minutes Approx. 16.8 miles	15 minutes Approx. 13.6 miles	0.8 inches	1.25 mile
1:100,000	30 minutes Approx. 33.6 miles	30 minutes Approx. 27.2 miles	1.6 inch	0.625 miles
1:250,000	1 degree Approx. 67.2 miles	2 degrees Approx. 108.8 miles	0.25 inch	4.0 miles
1:500,000	2 degrees Approx. 134.4 miles	6 degrees Approx. 326.4 miles	0.125 inch	8.0 miles

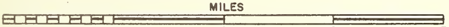
Below are scales for each Quadrangle Map Series in graphic form - by bars marked in miles.

BAR SCALES

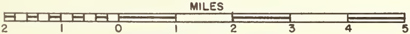
ARMY MAP SERVICE QUADRANGLES



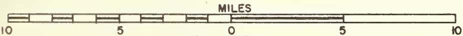
7.5' N-S by 7.5' E-W
(1:25,000 Scale)



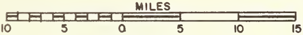
15' N-S by 15' E-W
(1:50,000 Scale)



30' N-S by 30' E-W
(1:100,000 Scale)



1° N-S by 2° E-W
(1:250,000 Scale)



2° N-S by 6° E-W
(1:500,000 Scale)

EXPLANATION AND USE OF THE UTM GRID

Map Projections

The most convenient way to precisely identify specific points on the curved surface of the earth is by means of a system of curved reference lines called parallels of latitude and meridians of longitude. On some maps the meridians and parallels appear as straight lines; on most modern maps, however, one set or the other, or both, appear as curves. These differences are due to the mathematical treatment required to portray a curved surface on a plane in such a manner that those properties of the map which are most important with respect to its intended use are shown with a minimum of distortion. The portrayal of a portion of the earth's curved surface on a flat surface is called a map projection.

Grids

To simplify the use of maps, and to avoid the inconvenience of curved reference lines, it is frequently convenient to superimpose on the map a rectangular grid consisting of two sets of straight, parallel lines, uniformly spaced, each set perpendicular to the other. These grids are carefully designed so that each is placed on the map in a specific location with respect to the meridians and parallels of the map projection. Thus, any point on the map can be designated by its latitude and longitude or by its grid coordinates, and a reference in either system can be converted precisely into a corresponding reference in the other system without ambiquity. Such grids are usually identified by the name of the particular projection for which they are designed.

UTM GRID

The Army Map Service has adopted a special grid for military use throughout the world. It is designated the Universal Transverse Mercator (UTM) grid. For this purpose, the world is divided into 60 North-South zones, each covering a strip 6° wide in longitude. (See Figure 1)

UTM Zones Extend 6° in Longitude

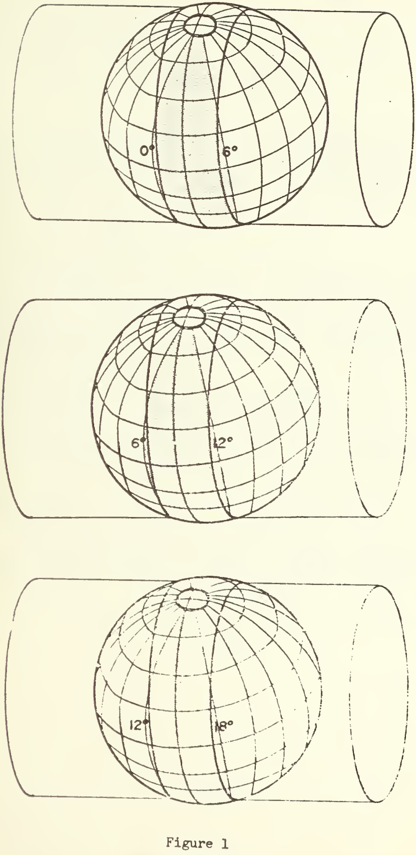


Figure 1

The 60 north-south zones of the world are numbered consecutively, beginning with zone 1 between 180° and 174° west longitude and progressing eastward to zone 60 between 174° and 180° east longitude. The United States is covered by 10 zones, from zone 10 on the west coast through zone 19 in New England (See figure 2).

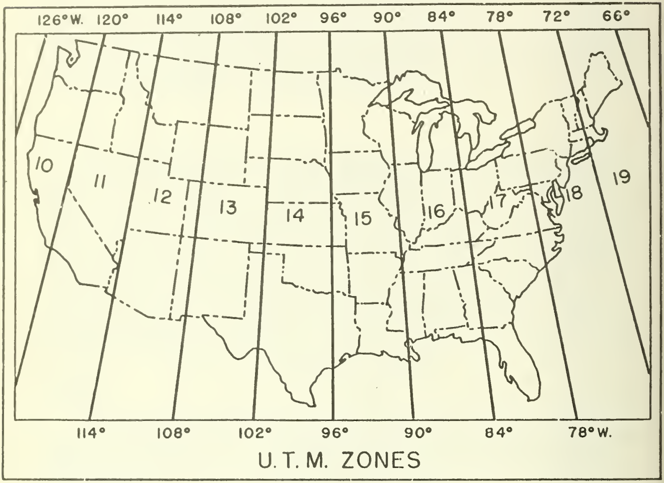


FIGURE 2.

USE OF THE UTM GRID ON VARIOUS PROJECTIONS

The Universal Transverse Mercator (UTM) grid was designed to be superimposed on the Transverse Mercator Projection because both the parallels (latitude lines) and the meridians (longitude lines) are straight lines. This, however, does not preclude the use of the UTM grid in connection with other projections.

The UTM grid may be used in Lambert's Conformal Conic Projection where the meridians are straight lines converging toward the poles and are equally spaced, true to scale on the standard parallel and where the parallels are arcs of concentric circles spaced wider apart toward the north and south. These factors do not affect the spacing of the northings, while the east and west margins of the UTM zones converge toward the poles.

Maps drawn on the Polyconic Projection may also employ the UTM grid when their meridians are curved, spaced equally, and are true on each parallel; and whose parallels are non-concentric cirlces, spaced truly on the central meridian. In the case of the Polyconic Projection which has curved meridians, the 6 degree UTM zones along the eastern and western margins are curved to conform with the curvature of the meridians.

Another common projection over which the UTM grid is superimposed is the Albers Equal Area Projection. In this projection the meridians are radiating straight lines from the pole, and are spaced equally and truly on two standard parallels, while the parallels are arcs of concentric circles spaced closer toward the north and south ends.

Regardless of the map projection, the most salient feature of the superimposition of the UTM grid is that the eastern and western borders of each 6 degree zone will conform to the meridians, while the northings will always be segments of a straight line within each zone, parallel to each other and equally spaced within each zone north of the equator.

The UTM Grid Superimposed on a Map of the United States

The following series of illustrations depict schematically the superimposition of the UTM Grid on a map of the United States.

Figure 3 delineates the central meridians for each UTM Zones in the United States. Each central meridian — drawn through the middle of the zone — is known as the 500,000 meter line. Each central meridian is located 3° inward from the boundaries of the UTM Zones. All points on the central meridians have an easting value of exactly 500,000 meters.

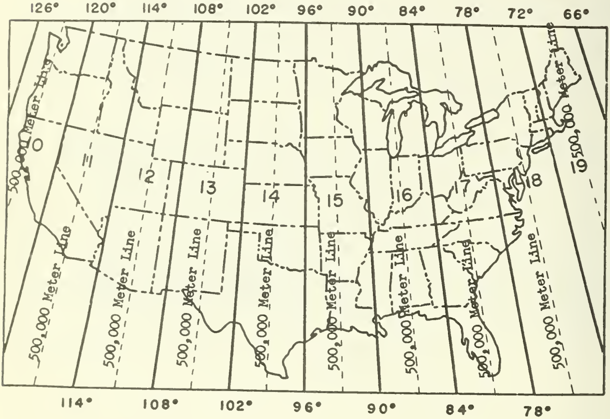


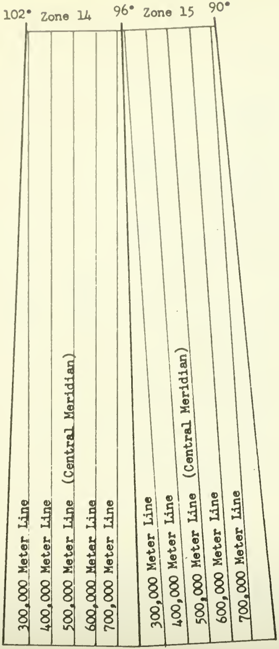
Figure 3

Figures 4a, b, c delineate, for Zones 14 and 15, the following:

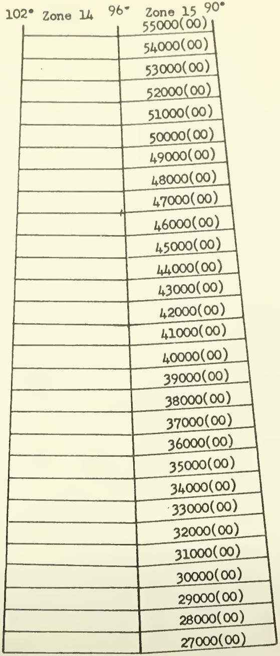
4a. Shows the 100,000 easting lines. Lines left of the central meridians have an easting value smaller than 500,000 meters; lines right of the central meridians have an easting value larger than 500,000 meters. Each line drawn through the middle of the Zone is the central longitude of the Zone and is known as the central meridian. It stretches from north to south. Each 100,000 meter line within a Zone is drawn at a right angle and parallel to the central meridian. Each line is known as an easting line.

4b. Shows the 100,000 northing lines. The northing lines, equally spaced at 100,000 meters, are drawn parallel to the equator. The northing lines stretch from west to east. The northing line at the equator has a zero meter value with each succeeding northing line from the equator continuously increasing in meter values by 100,000 meters. Thus, for example, illustration 4b depicts the bottom northing value as 2,700,000 meters, the next value as 2,800,000 meters — each succeeding 100,000 meter line increasing in meter value by 100,000 meters. The top northing line has a value of 5,500,000 meters.

4c. Shows the 100,000 meter grid formed by the intersection of the easting and northing lines.


102°
Zone 14
96°
Zone 15
90°
300,000 Meter Line
400,000 Meter Line
500,000 Meter Line (Central Meridian)
600,000 Meter Line
700,000 Meter Line
300,000 Meter Line
400,000 Meter Line
500,000 Meter Line (Central Meridian)
600,000 Meter Line
700,000 Meter Line

4 A


102°
Zone 14
96°
Zone 15
90°
55000(00)
54000(00)
53000(00)
52000(00)
51000(00)
50000(00)
49000(00)
48000(00)
47000(00)
46000(00)
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41000(00)
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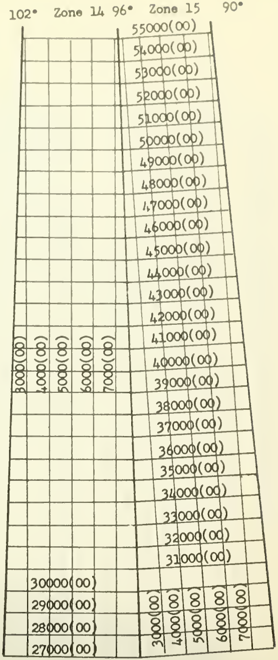
28000(00)
27000(00)

4 B


102°
Zone 14
96°
Zone 15
90°
55000(00)
54000(00)
53000(00)
52000(00)
51000(00)
50000(00)
49000(00)
48000(00)
47000(00)
46000(00)
45000(00)
44000(00)
43000(00)
42000(00)
41000(00)
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39000(00)
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37000(00)
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27000(00)
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4000(00)
5000(00)
6000(00)
7000(00)

4 C

A 100,000 meter square may be subdivided further, if desired, into 10,000 meter squares. Illustration figure 5 depicts a 100,000 meter square subdivided into 10,000 meter squares.

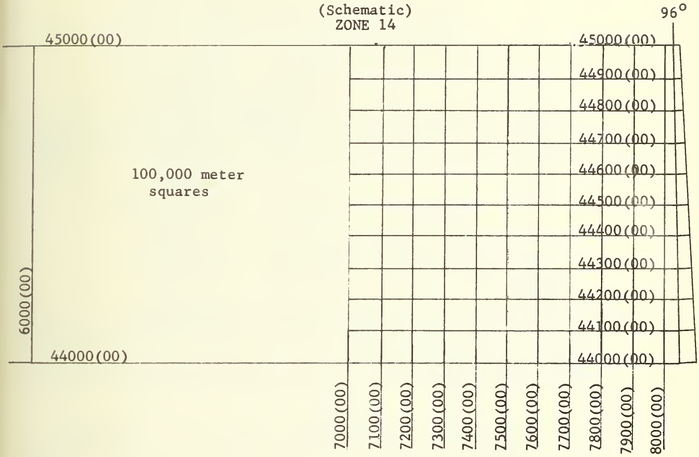


Fig. 5

Illustration figure 6 depicts a 10,000 meter square subdivided into 1,000 meter squares.

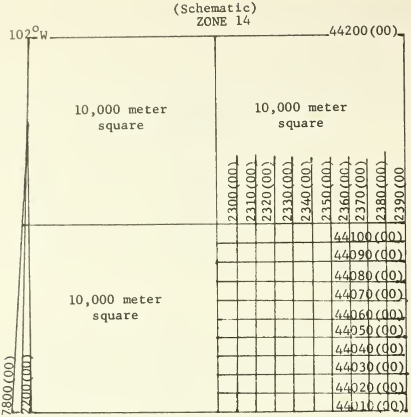


Fig. 6

Illustration figure 7 depicts a 1,000 meter square subdivided into 100 meter squares.

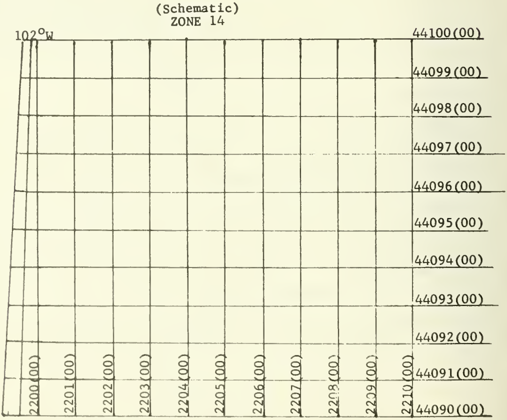


Fig. 7

The UTM Grid on AMS and USGS Maps

All Army Map Service maps show the UTM grid lines on the maps. The following lists for the various AMS map series the meter values for the size of grids used:

Scale 1:500,000 - 10,000 meter grid lines
Scale 1:250,000 - 10,000 meter grid lines
Scale 1:100,000 - 10,000 meter grid lines
Scale 1:50,000 - 1,000 meter grid lines
Scale 1:25,000 - 1,000 meter grid lines

The United States Geological Survey map series do not show the UTM grid lines. The UTM grid, however, is indicated by ticks in the margins of the maps. The following lists for the various USGS map series the meter values for the size of grids used:

Scale 1:250,000 - 10,000 meter grid ticks
Scale 1:62,500 - 1,000 meter grid tick (every 5th tick shows the meter value)
Scale 1:24,000 - 1,000 meter grid tick (every 5th tick shows the meter value)

For the 1:62,500 and 1:24,000 scale maps, the meter values for ticks nearest the southeast and northwest corners of the maps are also shown. At present, only a few of the USGS maps show the UTM grid information; however, to facilitate the use of USGS maps by civil defense personnel, USGS will henceforth show the UTM grid information on all quadrangle maps published.

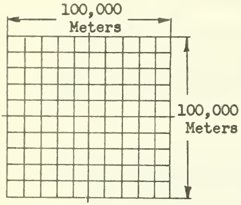
On the map of the United States - Scale 1:2,500,000 - prepared by USGS for Office of Civil and Defense Mobilization, the full grid lines are printed in red at intervals of 100,000 meters. Zone numbers are shown at the top and bottom of the map opposite the central meridian of each zone. Each central meridian carries its easting value, 500,000 meter, at both ends, and the northing value is shown in the right and left margins for each 1,000,000-meter line. In addition, each printed line is labeled with a single digit to indicate its 100,000-meter value within the larger block. Zone boundaries are shown by heavier red lines.

EFFECTS OF MAP SCALES ON ACCURACY OF UTM GRID COORDINATE READINGS

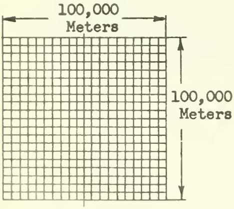
The degree of accuracy of a UTM grid coordinate reading depends on the scale of the map being used. In general, large scale maps furnish UTM grid coordinate readings of a higher accuracy than small scale maps. Maps with grids of 1,000 meter squares furnish more accurate UTM grid coordinate readings than maps with grids of 10,000 meter squares. Likewise, maps with grids of 10,000 meter squares furnish more accurate UTM grid coordinate readings than maps with grids of 100,000 meter squares.

The following grid squares, drawn to scale, illustrate the degree of accuracy of a UTM grid coordinate reading that can be achieved for the grids of 100,000 meter squares, 10,000 meter squares and 1,000 meter squares.

100,000 meter square
OCDM map of U. S. - 1:2,500,000 scale

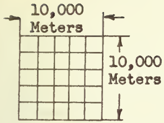


10,000 meter grid template. Accuracy of UTM grid coordinate reading - nearest 10,000 meters. Higher degree of accuracy achieved by interpolation only.

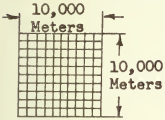


5,000 meter grid template. Accuracy of UTM grid coordinate reading - nearest 5,000 meters. Higher degree of accuracy achieved by interpolation only.

10,000 meter square
AMS 1:500,000 scale maps

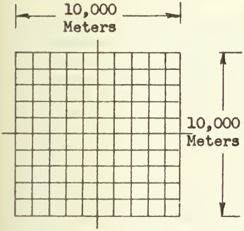


2,000 meter grid template. Accuracy of UTM grid coordinate reading - nearest 2,000 meters. Higher degree of accuracy achieved by interpolation only.

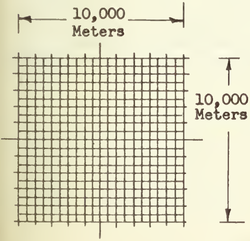


1,000 meter grid template. Accuracy of UTM grid coordinate reading - nearest 1,000 meters. Higher degree of accuracy achieved by interpolation only.

10,000 meter square
AMS and USGS - 1:250,000 scale maps

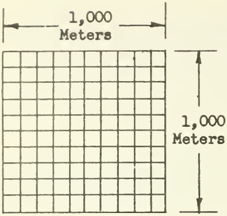


1,000 meter grid template. Accuracy of UTM grid coordinate reading - nearest 1,000 meters. Higher degree of accuracy achieved by interpolation only.



500 meter grid template. Accuracy of UTM grid coordinate reading - nearest 500 meters. Higher degree of accuracy achieved by interpolation only

1,000 meter square
AMS - 1:50,000 and 1:25,000 scale maps
USGS - 1:62,500 and 1:24,000 or 1:31,680 scale maps



100 meter grid template. Accuracy of UTM grid coordinate reading - nearest 100 meters. Higher degree of accuracy achieved by interpolation only.

Metric Grid Templates

A map containing too many lines not only looks cluttered but also is difficult to read. Maps, depicting the UTM grid system (squares), therefore, do not contain too many lines. Thus, maps with scales of 1:1,000,000, 1:1,500,000, 1:2,500,000 or more usually show only 100,000 meter squares. Maps with scales of 1:100,000, 1:250,000 and 1:500,000 usually show only 10,000 meter squares. Maps with scales of 1:24,000, 1:25,000, 1:31,680, 1:50,000 and 1:62,500 usually show only 1,000 meter squares.

Since point locations on a map are usually located within a grid square, to obtain a UTM grid coordinate often requires visual interpolation, that is estimating by eye the number of meters a point is located from the nearest northing and easting grid lines. To eliminate the process of visual interpolation and facilitate the reading of UTM grid coordinates it is advisable to develop translucent metric grid templates. The illustrations on pages 89 and 90 (12.11 and 12.12) are grid templates, drawn to scale, which may be used for developing translucent templates.

HOW TO READ THE UTM GRID COORDINATES

The UTM Grid system is a series of squares superimposed on the rectangular coordinates of the map projection. The northing and easting grid lines form the squares, and where they intersect they form a "grid coordinate". The location of a point on the map, therefore, is identified by its "grid coordinates". The "grid coordinates" of a point comprise three elements: 1. the UTM zone number within which the point is located 2. the number of meters it is located from the equator (its northing metric value) and 3. the number of meters from the left boundary of the zone within which it is located (its easting metric value). Since each UTM zone is identified by numerals and the northing and easting metric values are also expressed in numerals, the "grid coordinates" of a point are all expressed in numerals. OCDM does not employ alphabetic letters for identifying the "grid coordinates" of a point. Although the military utilizes a combination of alphabetic letters and numerals for identifying the UTM grid coordinates of a point, OCDM utilizes all numerals because electronic computers, which OCDM employs for damage assessment purposes, cannot measure distances unless the "grid coordinates" of locations are all expressed in meters. Alphabetic letters, unlike numbers, do not express metric values in meters.

The UTM "Grid coordinates" of a point on a U.S. map may be expressed to the nearest meter as a fifteen-digit number. The first two digits represent the zone number; the next seven digits represent the number of meters from the equator (northing) and the last six digits represent the number of meters from the left boundary of the zone in which the point is located. It is OCDM practice, however, to identify the "grid coordinates" of point on a U.S. map to the nearest northing 100 meter value and easting 100 meter value since all "grid coordinates" of locations within the OCDM damage assessment system have been identified to the nearest northing 100 meter value and easting 100 meter value. Thus, OCDM "grid coordinates" are customarily identified by an eleven (11) digit number. The first two numbers represent the zone number, the next five digits represent the northing metric value and the next four digits represent the easting metric value. The three separate elements of a "grid coordinate" are hyphenated so that the zone, northing, and easting will be easily identified, viz., 14-44000-7400.

OCDM records a UTM "grid coordinate" by listing: first, the zone numbers; second, the northing metric value, that is by reading up; third, the easting metric value, that is by reading across. The military, however, record a UTM "grid coordinate" by listing: first, the zone numbers; second, the easting metric value (alphabetic letters and numbers), that is by reading across; third, the northing metric value (alphabetic letters and numbers), that is by reading up. The reason OCDM reads and records first up and then across, rather than first across and then up as the military do, is because it enables an electronic computer to facilitate the computations.

The following illustration (figure 8) visually depicts how a UTM grid coordinate is read and recorded in accordance with OCDM practice and procedure.

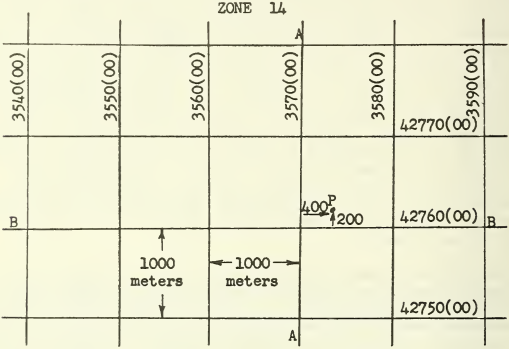


Figure 8

To read and record the UTM grid coordinate of point "P", it is necessary to note distance in meters at map scale, between any map point and the nearest grid lines to the south and west. The "northing" of point "P" is the value of the grid line just south of it plus its distance north of that line. The grid value of line B-B is 4,276,000 N. Thus, the northing of "P" is 4,276,200. The "easting" of point "P" is the value of the grid line just west of it plus its distance east of the line. The grid value of line A-A is 357,000 E. Thus, the easting of "P" is 357,400. The grid coordinates of point "P", therefore, is 14-42762-3574.

Explanation and Use of the World Geographic Reference System (GEOREF)

The World Geographic Reference System (abbreviated GEOREF) is a grid reference system which enables anyone to identify a location anywhere on the earth with a relatively high degree of accuracy depending on the scale of the map employed. On a small scale map, such as the OCDM map of the United States - scale 1:2,500,000, the degree of accuracy is approximately within 10 by 10 miles; on very large scale maps, however, a degree of accuracy within 1 by 1 mile may be achieved, if required.

The GEOREF system is based on the principle of division and subdivision. Figure 1 depicts a GEOREF map.

WORLD GEOGRAPHIC REFERENCE SYSTEM (GEOREF)

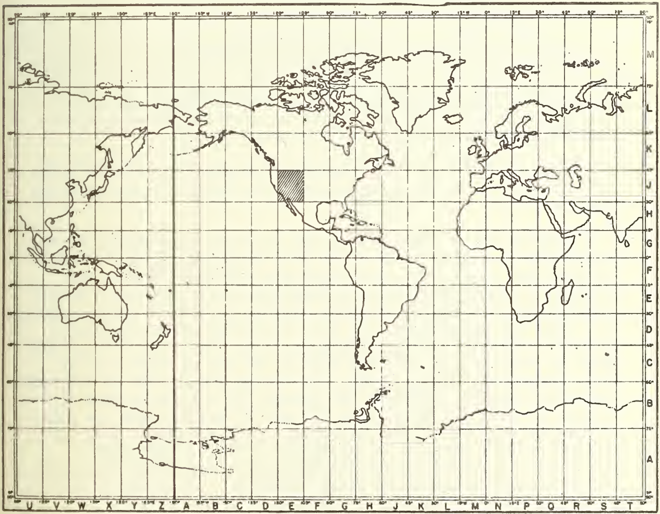


FIGURE 1.

In constructing a GEOREF system, the entire surface of the globe is divided into 12 latitude bands (each band comprising 15°) and 24 longitude zones (each zone comprising 15°) thus creating 288 quadrangles. Each quadrangle comprises 15° latitude by 15° longitude. The intersection of the South Pole and the 180° meridian is the base reference point for designating the 15° longitude zones. The 24 longitude zones stretch north-south from the North Pole to the South Pole. Each of the 24 longitude zones is identified by an alphabetic letter. Starting at the 180° meridian, the first longitude zone is identified "A", the next "B" and so forth - from left to right. The letters "I" and "O" are not used for identification purposes because "I" is confused with a Roman numeral and "O" is confused with zero and the letter "Q". Figure 2 identifies the individual longitude zones. The 12 latitude bands, parallel to the equator, stretch from west to east. Each 15° latitude band is identified by an alphabetic letter. Starting at the bottom, the first latitude band is identified by the letter "A", the next "B" and so forth through "M". The letter "I" is omitted. Figure 1 identifies the individual latitude bands.

Each 15° latitude by 15° longitude quadrangle is identified by two alphabetic letters. The first alphabetic letter represents the longitude zone; the second alphabetic letter represents the latitude band. Thus, for example, the shaded quadrangle on Figure 1 is identified as "EJ". Figure 2 shows the identification of each of the 288 quadrangles.

Each 15° latitude by 15° longitude is approximately 900 miles by 900 miles or 81,000 square miles. (One degree is approximately 60 miles.)

Each of the 15° latitude by 15° longitude quadrangles can be subdivided into 15 latitude bands (each band comprising 1°) and 15 longitude zones (each zone comprising 1°) thus creating 225 segments - each segment being 1° latitude by 1° longitude. The 1° latitude by 1° longitude segments, similar to the 15° latitude by 15° longitude quadrangles, are also identified by two alphabetic letters. Starting at the left-hand corner, the first 1° longitude zone is identified as "A", the next as "B" and so forth through "Q" - going from left to right. In similar manner, the 1° latitude bands are also identified as "A" through "Q" - going up from the bottom to the top. The letters "I" and "O" are not used for identification purposes. Each individual 1° latitude by 1° longitude segment is also assigned two alphabetic letters. The first alphabetic letter represents the longitude zone; the second alphabetic letter represents the latitude band.

World Geographic Reference System (GEOREF)

Schematic

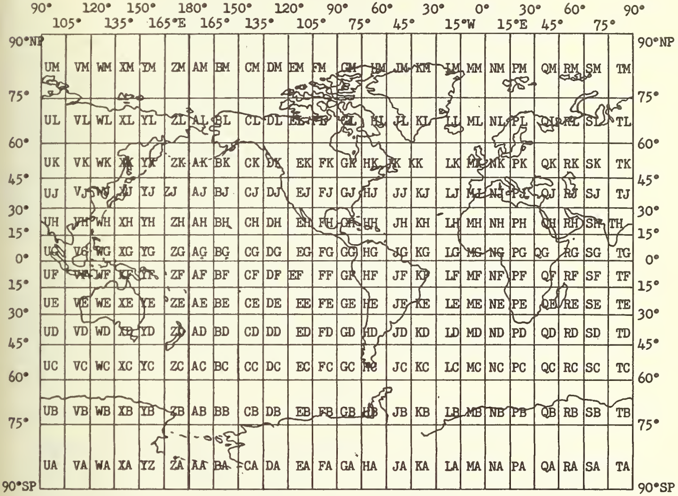
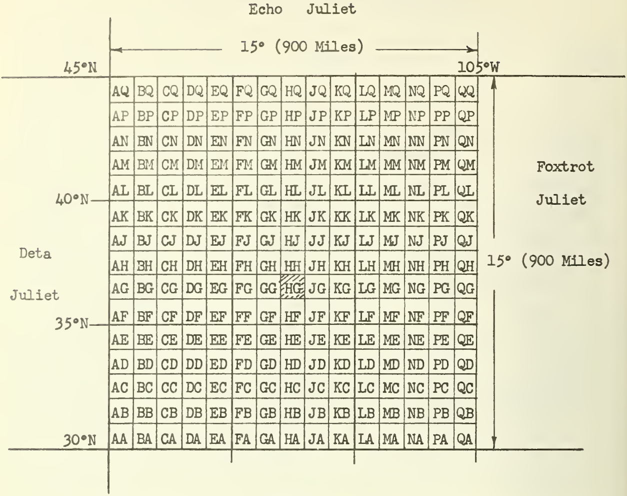

90° 120° 150° 180° 150° 120° 90° 60° 30° 0° 30° 60° 90°
105° 135° 165°E 165° 135° 105° 75° 45° 15°W 15°E 45° 75°
90°NP
75°
60°
45°
30°
15°
0°
15°
30°
45°
60°
75°
90°SP
UM VM WM XM YM ZM AM BM CM DM EM FM GM HM JM KM LM MM NM PM QM RM SM TM
UL VL WL XL YL ZL AL BL CL DL EL FL GL HL JL KL LL ML NL PL QL RL SL TL
UK VK WK XK YK ZK AK BK CK DK EK FK GK HK JK KK LK MK NK PK QK RK SK TK
UJ VJ WJ XJ YJ ZJ AJ BJ CJ DJ EJ FJ GJ HJ JJ KJ LJ MJ NJ PJ QJ RJ SJ TJ
UH VH WH XH YH ZH AH BH CH DH EH FH GH HH JH KH LH MH NH PH QH RH SH TH
UG VG WG XG YG ZG AG BG CG DG EG FG GG HG JG KG LG MG NG PG QG RG SG TG
UF VF WF XF YF ZF AF BF CF DF EF FF GF HF JF KF LF MF NF PF QF RF SF TF
UE VE WE XE YE ZE AE BE CE DE EE FE GE HE JE KE LE ME NE PE QE RE SE TE
UD VD WD XD YD ZD AD BD CD DD ED FD GD HD JD KD LD MD ND PD QD RD SD TD
UC VC WC XC YC ZC AC BC CC DC EC FC GC HC JC KC LC MC NC PC QC RC SC TC
UB VB WB XB YB ZB AB BB CB DB EB FB GB HB JB KB LB MB NB PB QB RB SB TB
UA VA WA XA YZ ZA AA BA CA DA EA FA GA HA JA KA LA MA NA PA QA RA SA TA
90°NP
75°
60°
45°
30°
15°
0°
15°
30°
45°
60°
75°
90°SP

Figure 2

Schematic



AQ	BQ	CQ	DQ	EQ	FQ	GQ	HQ	JQ	KQ	LQ	MQ	NQ	PQ	QQ
AP	BP	CP	DP	EP	FP	GP	HP	JP	KP	LP	MP	NP	PP	QP
AN	BN	CN	DN	EN	FN	GN	HN	JN	KN	LN	MN	NN	PN	QN
AM	BM	CM	DM	EM	FM	GM	HM	JM	KM	LM	MM	NM	PM	QM
AL	BL	CL	DL	EL	FL	GL	HL	JL	KL	LL	ML	NL	PL	QL
AK	BK	CK	DK	EK	FK	GK	HK	JK	KK	LK	MK	NK	PK	QK
AJ	BJ	CJ	DJ	EJ	FJ	GJ	HJ	JJ	KJ	LJ	MJ	NJ	PJ	QJ
AH	BH	CH	DH	EH	FH	GH	HH	JH	KH	LH	MH	NH	PH	QH
AG	BG	CG	DG	EG	FG	GG	HG	JG	KG	LG	MG	NG	PG	QG
AF	BF	CF	DF	EF	FF	GF	HF	JF	KF	LF	MF	NF	PF	QF
AE	BE	CE	DE	EE	FE	GE	HE	JE	KE	LE	ME	NE	PE	QE
AD	BD	CD	DD	ED	FD	GD	HD	JD	KD	LD	MD	ND	PD	QD
AC	BC	CC	DC	EC	FC	GC	HC	JC	KC	LC	MC	NC	PC	QC
AB	BB	CB	DB	EB	FB	GB	HB	JB	KB	LB	MB	NB	PB	QB
AA	BA	CA	DA	EA	FA	GA	HA	JA	KA	LA	MA	NA	PA	QA

Figure 3

The 1° latitude by 1° longitude segments are identified by the use of four alphabetic letters. The first two alphabetic letters identify the 15° latitude by 15° longitude quadrangle; the second two alphabetic letters identify the 1° latitude by 1° longitude segment. Thus, for example, the 1° latitude by 1° longitude shaded segment shown on Figure 3 is identified as "EJHG". Figure 3 depicts the 15° latitude by 15° longitude "EJ" quadrangle subdivided into 1° latitude by 1° longitude segments. Each segment is approximately 60 miles by 60 miles or 3,600 miles (1° is about 60 miles).

The 1° latitude by 1° longitude segments, if desired, may be further subdivided into 6 latitude bands (each band comprising 10') and 6 longitude zones (each zone comprising 10') thus creating 36 blocks - each block being 10' latitude by 10' longitude. Thus, for example, Figure 4 depicts the subdivision of segment "EJHG" into 36 blocks. Each 10' latitude by 10' longitude block is identified by the use of a two-digit numeral. The first numeral identifies the 10' longitude zone; the second numeral identifies the 10' latitude band. The numeral scheme employed is depicted in Figure 4. Each 10' latitude by 10' longitude block is approximately 10 miles by 10 miles or 100 square miles.

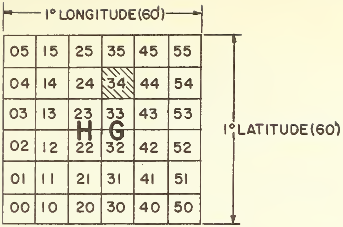


FIGURE 4.

The 10' latitude by 10' longitude blocks are identified by the use of four alphabetic letters and two numeral digits. Thus, for example, the 10' latitude by 10' longitude shaded block shown on Figure 4 is identified as "EJHG34".

Each 10' latitude by 10' longitude block may be further subdivided if a higher degree of accuracy is desired. However, Nuclear Detonation (NUDET) reports, transmitted by military organizations, usually do not utilize more than four alphabetic letters and two numerals. Therefore, the subdivision of 10' latitude by 10' longitude blocks is not required.

When transmitting orally GEOREF information, the phonetic alphabet is used since the alphabetic letters "B" and "P"; "C" and "Z"; "D" and "T"; and "E" and "G" sound almost identical when transmitted orally. By using the phonetic alphabet, however, errors in transmitting grid coordinates are eliminated. In the phonetic alphabet, each letter is assigned a phonetic word which is distinct in sound and different from any other word used. Thus, for example, "EJHG 34" would be transmitted as follows:

Echo Juliet Hotel Golf 3(Thu-Ree) 4(Fo-wer)

The Phonetic Alphabet is as follows:

A - Alfa
B - Bravo
C - Charlie
D - Deta
E - Echo
F - Foxtrot
G - Golf
H - Hotel
I - India
J - Juliet
K - Kilo
L - Lima
M - Mike
N - November
O - Oscar
P - Papa
Q - Quebec
R - Romeo
S - Sierra
T - Tango
U - Uniform
V - Victor
W - Whiskey
X - X-Ray
Y - Yankee
Z - Zulu

When the numbers are communicated orally, they are pronounced as follows:

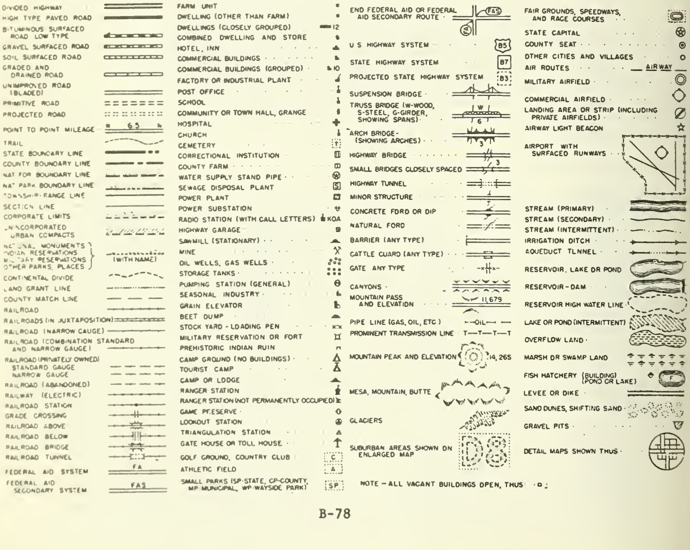
0 - Zee-Row
1 - Wun
2 - Too
3 - Thu-Ree
4 - Fo-wer
5 - Fi-yiv
6 - Six
7 - Sev-ven
8 - Ait
9 - Ni-ner

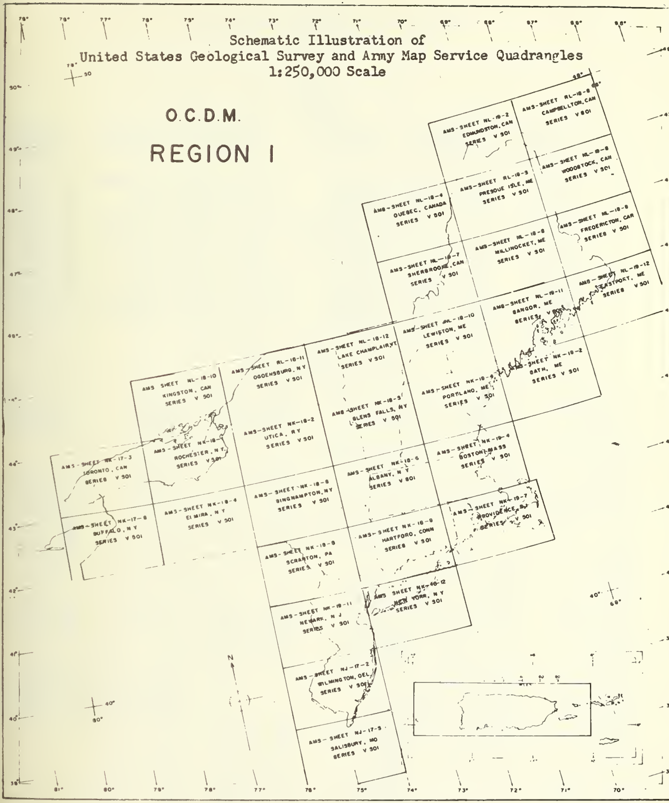
General Highway Maps

These maps are prepared by the State Highway Departments in cooperation with the U. S. Department of Commerce, Bureau of Public Roads. The General Highway Maps are county maps and show cultural features, including railroads, roads, political boundaries, dwelling and farm units, groups of buildings, hotels, schools, churches, airports, and so forth. The projection used is polyconic and the maps are published in different scales. However, the one inch equals one mile scale should be obtained because it presents the detailed information indicated on the maps sufficiently large to be easily seen.

General Highway Maps are usually not as accurate as the USGS or AMS quadrangles. However, because of the detailed information shown on them for counties, these maps will be found very useful for support planning purposes.

General Legend found on General Highway Maps.





Schematic Illustration of
United States Geological Survey and Army Map Service Quadrangles
1:250,000 Scale

O.C.D.M.

REGION I

Region 1
United States Geological Survey and Army Map Service Quadrangles

1:250.000 Scale

REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Albany	NI - 18- 6	Houlton	NL - 19- 6	Providence	NK - 19- 7
Bangor	NL - 19-11	Jackman	NL - 19- 7	Quebec	NL - 19- 4
Bath	NK - 19- 2	Kingston	NL - 18-10	Rochester	NK - 18- 1
Binghamton	NK - 18- 5	Lake Champlain	NL - 18-12	Salisbury	NJ - 18- 5
Boston	NK - 19- 4	Lewiston	NL - 19-10	Scranton	NK - 18- 8
Buffalo	NK - 17- 6	Millinocket	NL - 19- 8	Toronto	NK - 17- 3
Calais	NL - 19- 9	Newark	NK - 18-11	Utica	NK - 18- 2
Eastport	NH - 19-12	New York	NK - 18-12	Van Buren	NL - 19- 3
Elmira	NK - 18- 4	Ogdenburg	NL - 18-11	Wilmington	NJ - 18- 2
Glen Falls	NK - 18- 3	Portland	NK - 19- 1		
Hartford	NK - 18- 9	Presque Isle	NL - 19- 5		

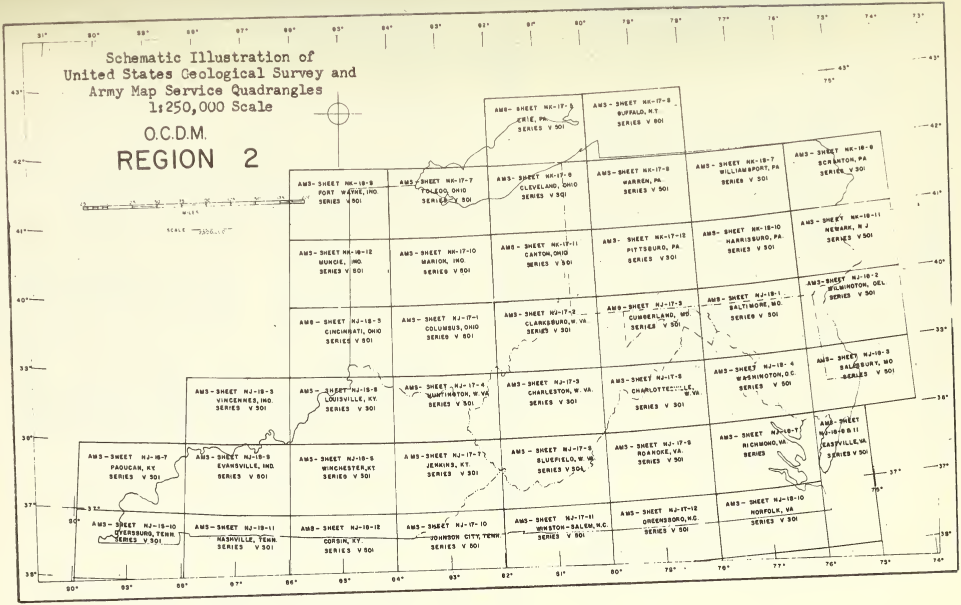
STATES WITHIN REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Conhecticut		New Hampshire		New York	
Boston	NK - 19- 4	Albany	NK - 18- 6	(cont'd)	
Hartford	NK - 18- 9	Boston	NK - 19- 4	Ogdenburg	NL - 18-11
New York	NK - 18-12	Glens Falls	NK - 18- 3	Rochester	NK - 18- 1
Providence	NK - 19- 7	Jackman	NL - 19- 7	Scranton	NK - 18- 8
		Lake Champlain	NL - 18-12	Toronto	NK - 17- 3
Maine		Lewiston	NL - 19-10	Utica	NK - 18- 2
Bangor	NL - 19-11	Portland	NK - 19- 1	Williamsport	NK - 18- 7
Bath	NK - 19- 2				
Boston	NK - 19- 4	New Jersey		Rhode Island	
Calais	NL - 19- 9	Newark	NK - 18-11	Boston	NK - 19- 4
Eastport	NL - 19-12	New York	NK - 18-12	Providence	NK - 19- 7
Ft. Kent	NL - 19- 2	Salisbury	NJ - 18- 5		
Houlton	NL - 19- 6	Scranton	NK - 18- 5	Vermont	
Jackman	NL - 19- 7	Wilmington	NJ - 18- 2	Albany	NK - 18- 6
Lewiston	NL - 19-10			Glen Falls	NK - 18- 3
Millinocket	NL - 19- 8	New York		Lake Champlain	NL - 18-12
Portland	NK - 19- 1	Albany	NK - 18- 6	Lewiston	NL - 19-10
Presque Isle	NL - 19- 5	Binghampton	NK - 18- 5		
Quebec	NL - 19- 4	Buffalo	NK - 17- 6		
Van Buren	NL - 19- 3	Elmira	NK - 18- 4		
		Glen Falls	NK - 18- 3		
Massachusetts		Hartford	NK - 18- 9		
Albany	NK - 18- 6	Kingston	NL - 18-10		
Boston	NK - 19- 4	Lake Champlain	NL - 18-12		
Hartford	NK - 18- 9	Newark	NK - 18-11		
Providence	NK - 19- 7	New York	NK - 18-12		

Schematic Illustration of United States Geological Survey and Army Map Service Quadrangles 1:250,000 Scale

O.C.D.M.

REGION 2



AMS-SHEET NK-17-5 ERIE, PA. SERIES V 501
AMS-SHEET NK-17-6 BUFFALO, N.Y. SERIES V 501
AMS-SHEET NK-16-9 FORT WAYNE, IND. SERIES V 501
AMS-SHEET NK-17-7 TOLEDO, OHIO SERIES V 501
AMS-SHEET NK-17-8 CLEVELAND, OHIO SERIES V 501
AMS-SHEET NK-17-9 WARREN, PA. SERIES V 501
AMS-SHEET NK-18-7 WILLIAMSPORT, PA SERIES V 501
AMS-SHEET NK-18-8 SCRANTON, PA SERIES V 501
AMS-SHEET NK-16-12 MUNCIE, IND. SERIES V 501
AMS-SHEET NK-17-10 MARION, IND. SERIES V 501
AMS-SHEET NK-17-11 CANTON, OHIO SERIES V 501
AMS-SHEET NK-17-12 PITTSBURG, PA SERIES V 501
AMS-SHEET NK-18-10 HARRISBURG, PA. SERIES V 501
AMS-SHEET NK-18-11 NEWARK, N J SERIES V 501
AMS-SHEET NJ-16-3 CINCINNATI, OHIO SERIES V 501
AMS-SHEET NJ-17-1 COLUMBUS, OHIO SERIES V 501
AMS-SHEET NJ-17-2 CLARKSBURG, W. VA SERIES V 501
AMS-SHEET NJ-17-3 CUMBERLAND, MD. SERIES V 501
AMS-SHEET NJ-18-1 BALTIMORE, MD. SERIES V 501
AMS-SHEET NJ-18-2 WILMINGTON, DEL. SERIES V 501
AMS-SHEET NJ-16-5 VINCENNES, IND. SERIES V 501
AMS-SHEET NJ-16-6 LOUISVILLE, KY. SERIES V 501
AMS-SHEET NJ-17-4 HUNTINGTON, W. VA SERIES V 501
AMS-SHEET NJ-17-5 CHARLESTON, W. VA. SERIES V 501
AMS-SHEET NJ-17-6 CHARLOTTESVILLE, W. VA. SERIES V 501
AMS-SHEET NJ-18-4 WASHINGTON, D.C. SERIES V 501
AMS-SHEET NJ-18-5 SALISBURY, MD SERIES V 501
AMS-SHEET NJ-16-7 PADUCAH, KY SERIES V 501
AMS-SHEET NJ-16-8 EVANSVILLE, IND. SERIES V 501
AMS-SHEET NJ-16-9 WINCHESTER, KY. SERIES V 501
AMS-SHEET NJ-17-7 JENKINS, KY. SERIES V 501
AMS-SHEET NJ-17-8 BLUEFIELD, W. VA. SERIES V 501
AMS-SHEET NJ-17-9 ROANOKE, VA. SERIES V 501
AMS-SHEET NJ-18-7 RICHMOND, VA. SERIES
AMS-SHEET NJ-18-8 & 11 EASTVILLE, VA. SERIES V 501
AMS-SHEET NJ-16-10 DYERSBURG, TENN. SERIES V 501
AMS-SHEET NJ-16-11 NASHVILLE, TENN. SERIES V 501
AMS-SHEET NJ-16-12 CORBIN, KY. SERIES V 501
AMS-SHEET NJ-17-10 JOHNSON CITY, TENN. SERIES V 501
AMS-SHEET NJ-17-11 WINSTON-SALEM, N.C. SERIES V 501
AMS-SHEET NJ-17-12 GREENSBORO, N.C. SERIES V 501
AMS-SHEET NJ-18-10 NORFOLK, VA SERIES V 501
MILES
SCALE
91° 90° 89° 88° 87° 86° 85° 84° 83° 82° 81° 80° 79° 78° 77° 76° 75° 74° 73°
43° 42° 41° 40° 39° 38° 37° 36°

Region 2
United States Geological Survey and Army Map Service Quadrangles

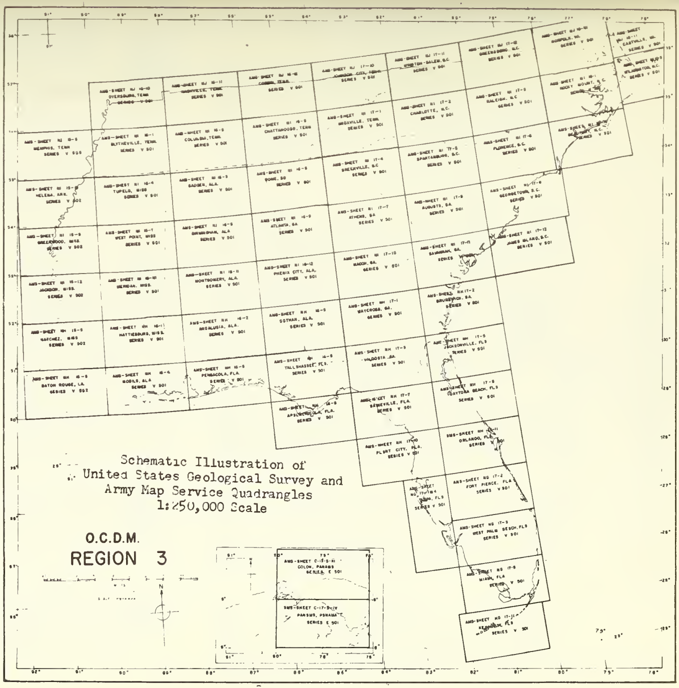
1:250,000 Scale

REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Baltimore	NJ - 18- 1	Erie	NK - 17- 5	Paducah	NJ - 16- 7
Bluefield	NJ - 17- 8	Evansville	NJ - 16- 8	Pittsburgh	NK - 17-12
Buffalo	NK - 17- 6	Fort Wayne	NK - 16- 9	Richmond	NJ - 18- 7
Canton	NK - 17-11	Greensboro	NJ - 17-12	Roanoke	NJ - 17- 9
Charleston	NJ - 17- 5	Harrisburg	NK - 18-10	Salisbury	NJ - 18- 5
Charlottesville	NJ - 17- 6	Huntington	NJ - 17- 4	Scranton	NK - 18- 8
Cincinnati	NJ - 16- 3	Jenkins	NJ - 17- 7	Toledo	NK - 17- 7
Clarksburg	NJ - 17- 2	Johnson City	NJ - 17-10	Vincennes	NJ - 16- 5
Cleveland	NK - 17- 8	Louisville	NJ - 16- 6	Warren	NK - 17- 9
Columbus	NJ - 17- 1	Marion	NK - 17-10	Washington, D.C.	NJ - 18- 4
Corbin	NJ - 16- 2	Muncie	NK - 16-12	Williamsport	NK - 18- 7
Cumberland	NH - 17- 3	Nashville	NJ - 16-11	Wilmington	NJ - 18- 2
Dyersburg	NJ - 16-10	Newark	NK - 18-11	Winchester	NJ - 16- 9
Eastville	NJ - 18-8, 11	Norfolk	NJ - 18-10	Winston-Salem	NJ - 17-11

STATES WITHIN REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Delaware		Ohio		Virginia	
Salisbury	NJ - 18- 5	Canton	NK - 17-11	Baltimore	NJ - 18- 1
Wilmington	NJ - 18- 2	Charleston	NJ - 17- 5	Bluefield	NJ - 17- 8
		Cincinnati	NJ - 16- 3	Charlottesville	NJ - 17- 6
Kentucky		Clarksburg	NJ - 17- 2	Cumberland	NJ - 17- 3
Bluefield	NI - 17- 9	Cleveland	NK - 17- 8	Eastville	NJ - 18-8,11
Cincinnati	NJ - 16- 3	Columbus	NJ - 17- 1	Greensboro	NJ - 17-12
Corbin	NJ - 16-12	Ft. Wayne	NK - 16- 9	Jenkins	NI - 17- 7
Dyersburg	NJ - 16-10	Huntington	NJ - 17- 4	Johnson City	NI - 17-10
Evansville	NJ - 16- 8	Louisville	NJ - 16- 6	Norfolk	NJ - 18-10
Huntington	NJ - 17- 4	Marion	NK - 17-10	Richmond	NJ - 18- 7
Jenkins	NI - 17- 7	Muncie	NK - 16-12	Roanoke	NJ - 17- 9
Johnson City	NI - 17-10	Toledo	NK - 17- 7	Washington, D.C.	NJ - 18- 4
Louisville	NJ - 16- 6			Winston-Salem	NJ - 17-11
Nashville	NJ - 16-11	Pennsylvania			
Paducah	NJ - 16- 7	Baltimore	NJ - 18- 1	West Virginia	
Vincennes,	NJ - 16- 5	Buffalo	NK - 17- 6	Baltimore	NJ - 18- 1
Winchester	NJ - 16- 9	Canton	NK - 17-11	Bluefield	NJ - 17- 8
		Clarksburg	NJ - 17- 2	Canton	NK - 17-11
Maryland		Cleveland	NK - 17- 8	Charleston	NJ - 17- 5
Baltimore	NJ - 18- 1	Cumberland	NJ - 17- 3	Charlottesville	NJ - 17- 6
Cumberland	NJ - 17- 3	Erie	NK - 17- 5	Clarksburg	NJ - 17- 2
Eastville	NJ - 18-8, 11	Harrisburg	NK - 18-10	Cumberland	NJ - 17- 3
		Newark	NK - 18-11	Huntington	NJ - 17- 4
Richmond	NJ - 18- 7	Pittsburgh	NK - 17-12	Jenkins	NI - 17- 7
Salisbury	NJ - 18- 5	Scranton	NK - 18- 8	Roanoke	NI - 17- 9
Washington	NJ - 18- 4	Warren	NK - 17- 9		
Wilmington	NJ - 18- 2	Williamsport	NK - 18- 7		
		Wilmington	NJ - 18- 2		



Schematic Illustration of
United States Geological Survey and
Army Map Service Quadrangles
1:250,000 Scale

O.C.D.M.
REGION 3

AMS-SHEET NJ 16-10 DYERSBURG, TENN SERIES V 501
AMS-SHEET NJ 16-11 NASHVILLE, TENN SERIES V 501
AMS-SHEET NJ 16-12 CORINTH, TENN SERIES V 501
AMS-SHEET NJ 17-10 JOHNSON CITY, TENN SERIES V 501
AMS-SHEET NJ 17-11 WINSTON-SALEM, N.C. SERIES V 501
AMS-SHEET NJ 17-12 GREENSBORO, N.C. SERIES V 501
AMS-SHEET NJ 18-10 NORFOLK, VA. SERIES V 501
AMS-SHEET NJ 18-11 EASTVILLE, VA. SERIES V 501
AMS-SHEET NI 15-3 MEMPHIS, TENN SERIES V 502
AMS-SHEET NI 16-1 BLYTHEVILLE, TENN SERIES V 501
AMS-SHEET NI 16-2 COLUMBIA, TENN SERIES V 501
AMS-SHEET NI 16-3 CHATTANOOGA, TENN SERIES V 501
AMS-SHEET NI 17-1 KNOXVILLE, TENN SERIES V 501
AMS-SHEET NI 17-2 CHARLOTTE, N.C. SERIES V 501
AMS-SHEET NI 17-3 RALEIGH, N.C. SERIES V 501
AMS-SHEET NI 18-1 ROCKY MOUNT, N.C. SERIES V 501
AMS-SHEET NI 18-3 WILMINGTON, N.C. SERIES V 501
AMS-SHEET NI 15-6 HELENA, ARK. SERIES V 502
AMS-SHEET NI 16-4 TUPELO, MISS SERIES V 501
AMS-SHEET NI 16-5 GADSEN, ALA. SERIES V 501
AMS-SHEET NI 16-6 ROME, GA SERIES V 501
AMS-SHEET NI 17-4 GREENVILLE, S.C SERIES V 501
AMS-SHEET NI 17-5 SPARTANBURG, S.C. SERIES V 501
AMS-SHEET NI 17-6 FLORENCE, S.C. SERIES V 501
AMS-SHEET NI 18-4 BEAUFORT, N.C. SERIES V 501
AMS-SHEET NI 15-9 GREENWOOD, MISS. SERIES V 502
AMS-SHEET NI 16-7 WEST POINT, MISS SERIES V 501
AMS-SHEET NI 16-8 BIRMINGHAM, ALA SERIES V 501
AMS-SHEET NI 16-9 ATLANTA, GA SERIES V 501
AMS-SHEET NI 17-7 ATHENS, GA SERIES V 501
AMS-SHEET NI 17-8 AUGUSTA, GA. SERIES V 501
AMS-SHEET NI 17-9 GEORGETOWN, S.C. SERIES V 501
AMS-SHEET NI 15-12 JACKSON, MISS. SERIES V 502
AMS-SHEET NI 16-10 MERIDIAN, MISS. SERIES V 501
AMS-SHEET NI 16-11 MONTGOMERY, ALA. SERIES V 501
AMS-SHEET NI 16-12 PHENIX CITY, ALA. SERIES V 501
AMS-SHEET NI 17-10 MACON, GA. SERIES V 501
AMS-SHEET NI 17-11 SAVANNAH, GA. SERIES
AMS-SHEET NI 17-12 JAMES ISLAND, S.C. SERIES V 501
AMS-SHEET NH 15-3 NATCHEZ, MISS SERIES V 502
AMS-SHEET NH 16-1 HATTIESBURG, MISS. SERIES V 501
AMS-SHEET NH 16-2 ANDALUSIA, ALA. SERIES V 501
AMS-SHEET NH 16-3 DOTHAN, ALA. SERIES V 501
AMS-SHEET NH 17-1 WAYCROSS, GA. SERIES V 501
AMS-SHEET NH 17-2 BRUNSWICK, GA. SERIES V 501
AMS-SHEET NH 15-6 BATON ROUGE, LA. SERIES V 502
AMS-SHEET NH 16-4 MOBILE, ALA SERIES V 501
AMS-SHEET NH 16-5 PENSACOLA, FLA. SERIES V 501
AMS-SHEET NH 16-6 TALLAHASSEE, FLA. SERIES V 501
AMS-SHEET NH 17-4 VALDOSTA, GA. SERIES V 501
AMS-SHEET NH 17-5 JACKSONVILLE, FLA SERIES V 501
AMS-SHEET NH 16-9 APALACHICOLA, FLA. SERIES V 501
AMS-SHEET NH 17-7 GAINESVILLE, FLA. SERIES V 501
AMS-SHEET NH 17-8 DAYTONA BEACH, FLA SERIES V 501
AMS-SHEET NH 17-10 PLANT CITY, FLA. SERIES V 501
AMS-SHEET NH 17-11 ORLANDO, FLA. SERIES V 501
AMS-SHEET NG 17-1 & 4 TAMPA, FLA SERIES V 501
AMS-SHEET NG 17-2 FORT PIERCE, FLA SERIES V 501
AMS-SHEET NG 17-5 WEST PALM BEACH, FLA SERIES V 501
AMS-SHEET NG 17-8 MIAMI, FLA SERIES V 501
AMS-SHEET NG 17-11 KEY WEST, FLA SERIES V 501
AMS-SHEET C-17-5-III COLON, PANAMA SERIES E 501
AMS-SHEET C-17-5-IV PANAMA, PANAMA SERIES E 501
N

Region 3
United States Geological Survey and Army Map Service Quadrangles

1:250,000 Scale

REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Andalusia	NH - 16- 2	Gadsden	NI - 16- 5	Norfolk	NJ - 18-10
Apalachicola	NH - 16- 9	Gainesville	NH - 17- 7	Orlando	NH - 17-11
Athens	NI - 17- 7	Georgetown	NI - 17- 9	Pensacola	NH - 16- 5
Atlanta	NI - 16- 9	Greensboro	NJ - 17-12	Phenix City	NI - 16-12
Augusta	NI - 17- 8	Greenville	NI - 17- 4	Plant City	NH - 17-10
Beaufort	NI - 18- 4	Greenwood	NI - 15- 9	Raleigh	NI - 17- 3
Birmingham	NI - 16- 8	Hattiesburg	NH - 16- 1	Richmond	NJ - 18- 7
Blytheville	NI - 16- 1	Jackson	NI - 15-12	Rocky Mount	NI - 18- 1
Breton Sound	NH - 16- 7	Jacksonville	NH - 17- 5	Rome	NI - 16- 6
Brunswick	NH - 17- 2	James Island	NI - 17-12	Savannah	NI - 17-11
Charlotte	NI - 17- 2	Johnson City	NJ - 17-10	Spartanburg	NI - 17- 5
Chattanooga	NI - 16- 3	Key West	NH - 17-11	Tallahassee	NH - 16- 6
Columbia	NI - 16- 2	Knoxville	NI - 17- 1	Tampa	NG - 17-1,4
Corbin	NJ - 16-12	Macon	NI - 17-10	Tupelo	NI - 16- 4
Daytona Beach	NH - 17- 8	Meridian	NI - 16-10	Valdosta	NH - 17- 4
Dyersburg	NJ - 16-10	Miami	NG - 17- 8	Wanchese	NI - 18- 2
Dothan	NH - 16- 3	Mobile	NH - 16- 4	Waycross	NH - 17- 1
Eastville	NJ - 18-8,11	Montgomery	NI - 16-11	West Palm Beach	NG - 17- 5
Florence	NI - 17- 6	Nashville	NJ - 16-11	West Point	NI - 16- 7
Fort Pierce	NG - 17- 2	Natchez	NH - 15- 3	Winston-Salem	NJ - 17-11

STATES WITHIN REGION

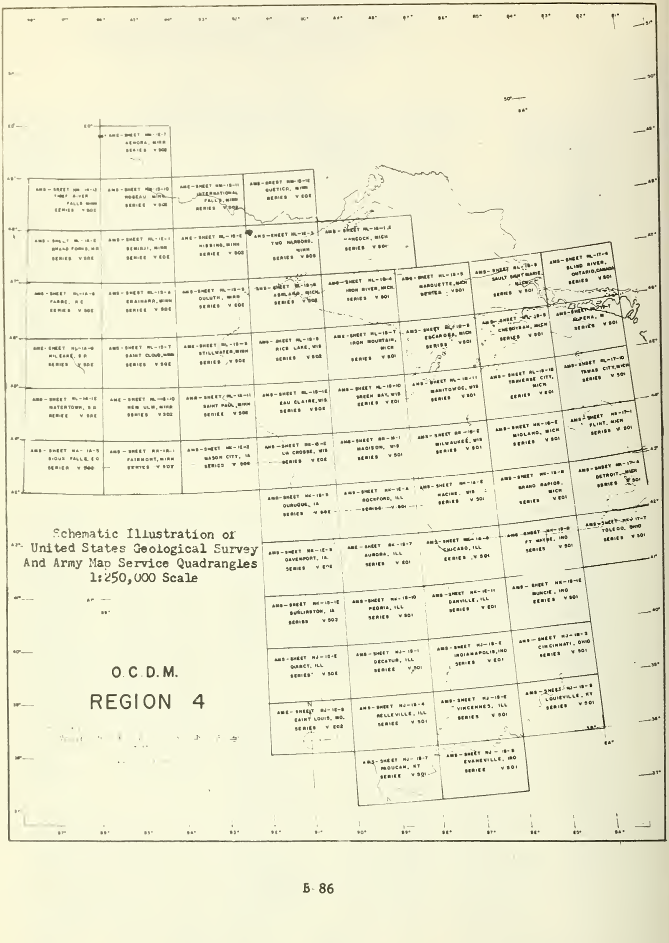
QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Alabama		Florida (cont'd)		Mississippi	
Andalusia	NH - 16- 2	Pensacola	NH - 16- 5	Baton Rouge	NH - 15- 6
Atlanta	NI - 16- 9	Plant City	NH - 17-10	Breton Sound	NH - 16- 7
Birmingham	NI - 16- 8	Tallahassee	NH - 16- 6	Greenwood	NI - 15- 9
Dothan	NH - 16- 3	Tampa	NG - 17-1,4	Hattiesburg	NH - 16- 1
Gadsden	NI - 16- 5	Valdosta	NH - 17- 4	Helena	NI - 15- 6
Hattiesburg	NH - 16- 1	West Palm Beach	NG - 17- 5	Jackson	NI - 15-12
Meridian	NI - 16-10			Meridian	NI - 16-10
Mobile	NH - 16- 4	Georgia		Mobile	NH - 16- 4
Montgomery	NI - 16-11	Athens	NI - 17- 7	Natchez	NH - 15- 3
Pensacola	NH - 16- 5	Atlanta	NI - 16- 9	Tupelo	NI - 16- 4
Phenix City	NI - 16-12	Augusta	NI - 17- 8	West Point	NI - 16- 7
Rome	NI - 16- 6	Brunswick	NH - 17- 2		
Tupelo	NI - 16- 4	Dothan	NH - 16- 3	North Carolina	
West Point	NI - 16- 7	Greenville	NI - 17- 4	Beaufort	NI - 18- 4
		Jacksonville	NH - 17- 5	Charlotte	NI - 17- 2
Florida		Macon	NI - 17-10	Chattanooga	NI - 16- 3
Apalachicola	NH - 16- 9	Phenix City	NI - 16-12	Eastville	NJ - 18-8,11
DaytonaBeach	NH - 17- 8	Rome	NI - 16- 6	Florence	NI - 17- 6
Dothan	NH - 16- 3	Savannah	NI - 17-11	Georgetown	NI - 17- 9
Ft. Pierce	NG - 17- 2	Tallahassee	NH - 16- 6	Greensboro	NJ - 17-12
Gainesville	NH - 17- 7	Valdosta	NH - 17- 4	Johnson City	NI - 17-10
Jacksonville	NH - 17- 5	Waycross	NH - 17- 1	Knoxville	NI - 17- 1
Key West	NG - 17-11			Norfolk	NJ - 18-10
Miami	NG 17- 8			Raleigh	NI - 17- 3
Orlando	NH - 17-11			Rocky Mount	NI - 18- 1

Region 3 (cont'd)
United States Geological Survey and
Army Map Service Quadrangles

1:250,000 Scale

STATES WITHIN REGION

QUADRANGLE NAME	QUADRANGLE NUMBER
North Carolina (cont'd)	
Spartansburg	NI - 17- 5
Wanchese	NI - 18- 2
Winston-Salem	NJ - 17-11
South Carolina	
Athens	NI - 17- 7
Augusta	NI - 17- 8
Charlotte	NI - 17- 2
Florence	NI - 17- 6
Greenville	NI - 17- 4
Georgetown	NI - 17- 9
James Island	NI - 17-12
Knoxville	NI - 17- 1
Spartansburg	NI - 17- 5
Savannah	NI - 17-11
Tennessee	
Blytheville	NI - 16- 1
Chattanooga	NI - 16- 3
Columbia	NI - 16- 2
Corbin	NJ - 16-12
Dyersburg	NJ - 16-10
Johnson City	NI - 17-10
Knoxville	NI - 17- 1
Memphis	NI - 15- 3
Nashville	NJ - 16-11
Winston-Salem	NJ - 17-11



AMS-SHEET NM 15-7 KENORA, MINN SERIES V502
AMS-SHEET NM 14-12 THIEF RIVER FALLS MINN SERIES V502
AMS-SHEET NM-15-10 ROSEAU MINN SERIES V502
AMS-SHEET NM-15-11 INTERNATIONAL FALLS, MINN SERIES V502
AMS-SHEET NM-15-12 QUETICO, MINN SERIES V502
AMS-SHEET NL-14-3 GRAND FORKS, N.D. SERIES V502
AMS-SHEET NL-15-1 BEMIDJI, MINN SERIES V502
AMS-SHEET NL-15-2 HIBBING, MINN SERIES V502
AMS-SHEET NL-15-3 TWO HARBORS, MINN SERIES V502
AMS-SHEET NL-16-1,2 HANCOCK, MICH SERIES V501
AMS-SHEET NL-14-6 FARGO, N.D. SERIES V502
AMS-SHEET NL-15-4 BRAINERD, MINN SERIES V502
AMS-SHEET NL-15-5 DULUTH, MINN SERIES V502
AMS-SHEET NL-15-6 ASHLAND, MICH. SERIES V502
AMS-SHEET NL-16-4 IRON RIVER, MICH. SERIES V501
AMS-SHEET NL-16-5 MARQUETTE, MICH SERIES V501
AMS-SHEET NL-16-6 SAULT SAINT MARIE, MICH SERIES V501
AMS-SHEET NL-17-4 BLIND RIVER, ONTARIO, CANADA SERIES V501
AMS-SHEET NL-14-9 MILBANK, S.D. SERIES V502
AMS-SHEET NL-15-7 SAINT CLOUD, MINN SERIES V502
AMS-SHEET NL-15-8 STILLWATER, MINN SERIES V502
AMS-SHEET NL-15-9 RICE LAKE, WIS SERIES V502
AMS-SHEET NL-16-7 IRON MOUNTAIN, MICH SERIES V501
AMS-SHEET NL-16-8 ESCANABA, MICH SERIES V501
AMS-SHEET NL-16-9 CHEBOYGAN, MICH SERIES V501
AMS-SHEET NL-17-7 ALPENA, M SERIES V501
AMS-SHEET NL-14-12 WATERTOWN, S.D. SERIES V502
AMS-SHEET NL-15-10 NEW ULM, MINN SERIES V502
AMS-SHEET NL-15-11 SAINT PAUL, MINN SERIES V502
AMS-SHEET NL-15-12 EAU CLAIRE, WIS SERIES V502
AMS-SHEET NL-16-10 GREEN BAY, WIS SERIES V501
AMS-SHEET NL-16-11 MANITOWOC, WIS SERIES V501
AMS-SHEET NL-16-12 TRAVERSE CITY, MICH SERIES V501
AMS-SHEET NL-17-10 TAWAS CITY, MICH SERIES V501
AMS-SHEET NK-14-3 SIOUX FALLS, S.D. SERIES V502
AMS-SHEET NK-15-1 FAIRMONT, MINN SERIES V502
AMS-SHEET NK-15-2 MASON CITY, IA SERIES V502
AMS-SHEET NK-15-3 LA CROSSE, WIS SERIES V502
AMS-SHEET NK-16-1 MADISON, WIS SERIES V501
AMS-SHEET NK-16-2 MILWAUKEE, WIS SERIES V501
AMS-SHEET NK-16-3 MIDLAND, MICH SERIES V501
AMS-SHEET NK-17-1 FLINT, MICH SERIES V501
AMS-SHEET NK-15-6 DUBUQUE, IA SERIES V502
AMS-SHEET NK-16-4 ROCKFORD, ILL SERIES V501
AMS-SHEET NK-16-5 RACINE, WIS SERIES V501
AMS-SHEET NK-16-6 GRAND RAPIDS, MICH SERIES V501
AMS-SHEET NK-17-4 DETROIT, MICH SERIES V501
AMS-SHEET NK-15-9 DAVENPORT, IA. SERIES V502
AMS-SHEET NK-16-7 AURORA, ILL SERIES V501
AMS-SHEET NK-16-8 CHICAGO, ILL SERIES V501
AMS-SHEET NK-16-9 FT WAYNE, IND SERIES V501
AMS-SHEET NK-17-7 TOLEDO, OHIO SERIES V501
AMS-SHEET NK-15-12 BURLINGTON, IA SERIES V502
AMS-SHEET NK-16-10 PEORIA, ILL SERIES V501
AMS-SHEET NK-16-11 DANVILLE, ILL SERIES V501
AMS-SHEET NK-16-12 MUNCIE, IND SERIES V501
AMS-SHEET NJ-15-3 QUINCY, ILL SERIES V502
AMS-SHEET NJ-16-1 DECATUR, ILL SERIES V501
AMS-SHEET NJ-16-2 INDIANAPOLIS, IND SERIES V501
AMS-SHEET NJ-16-3 CINCINNATI, OHIO SERIES V501
AMS-SHEET NJ-15-6 SAINT LOUIS, MO. SERIES V502
AMS-SHEET NJ-16-4 BELLEVILLE, ILL SERIES V501
AMS-SHEET NJ-16-5 VINCENNES, ILL SERIES V501
AMS-SHEET NJ-16-6 LOUISVILLE, KY SERIES V501
AMS-SHEET NJ-16-7 PADUCAH, KY SERIES V501
AMS-SHEET NJ-16-8 EVANSVILLE, IND SERIES V501
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Schematic Illustration of
United States Geological Survey
And Army Map Service Quadrangles
1:250,000 Scale

O.C.D.M.

REGION 4

Region 4

United States Geological Survey and Army Map Service Quadrangles

1:250,000 Scale

REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Alpena	NL - 17- 4	Grand Rapids	NK - 16- 6	Muncie	NK - 16-12
Ashland	NL - 15- 6	Green Bay	NL - 16-10	Nebraska City	NK - 15-10
Aurora	NK - 16- 7	Hancock	NL - 16- 1	Paducah	NJ - 16- 7
Belleville	NJ - 16- 4	Harrison	NJ - 15-11	Peoria	NK - 16-10
Blytheville	NI - 16- 1	Indianapolis	NJ - 16- 2	Popular Bluff	NJ - 15-12
Burlington	NK - 15-12	Iron Mountain	NL - 16- 7	Quincy	NJ - 15- 3
Centerville	NK - 15-11	Iron River	NL - 16- 4	Racine	NK - 16- 5
Chicago	NK - 16- 8	Jefferson City	NJ - 15- 5	Rice Lake	NL - 15- 9
Cincinnati	NJ - 16- 3	Joplin	NJ - 15- 7	Rockford	NK - 16- 4
Danville	NK - 10-11	Kansas City	NJ - 15- 1	Rolla	NJ - 15- 9
Davenport	NK - 15- 9	La Crosse	NK - 15- 3	Springfield	NJ - 15- 8
Decatur	NJ - 16- 1	Lawrence	NJ - 15- 4	Stillwater	NL - 15- 8
Detroit	NK - 17- 4	Louisville	NJ - 16- 6	St. Louis	NJ - 15- 6
Dubuque	NK - 15- 6	Madison	NK - 16- 1	St. Paul	NL - 15-11
Duluth	NL - 15- 6	Manitowac	NL - 16-11	Tawas City	NL - 17- 7
Dyersburg	NJ - 16-10	Marquette	NL - 16- 5	Toledo	NK - 17- 7
Eau Clair	NL - 15-12	Memphis	NI - 15- 3	Traverse City	NL - 16-12
Escanaba	NL - 16- 8	Midland	NK - 16- 3	Tulsa	NJ - 15-10
Evansville	NJ - 16- 8	Milwaukee	NK - 16- 2	Two Harbors	NL - 15- 3
Flint	NK - 17- 1	Moberly	NJ - 15- 2	Vincennes	NJ - 16- 5
Fort Wayne	NK - 16- 9				

STATES WITHIN REGION

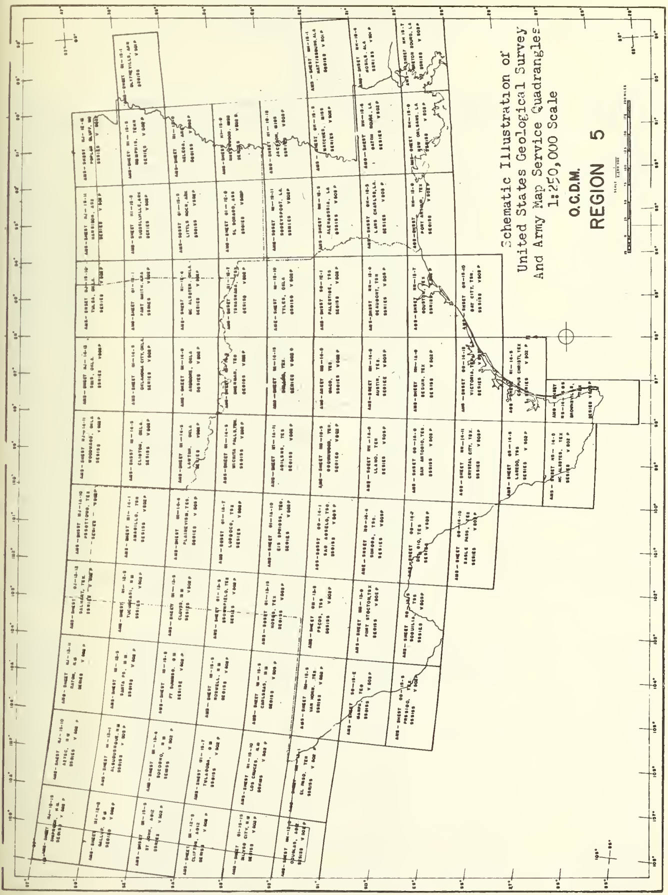
QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Illinois		Indiana		Michigan (cont'd)	
Aurora	NK - 16- 7	Chicago	NK - 16- 8	Ft. Wayne	NK - 16- 9
Belleville	NJ - 16- 4	Cincinnati	NJ - 16- 3	Grand Rapids	NK - 16- 6
Burlington	NK - 15-12	Danville	NK - 16-11	Hancock	NL - 16- 1
Chicago	NK - 16- 8	Evansville	NJ - 16- 8	Iron Mountain	NL - 16- 7
Danville	NK - 16-11	Ft. Wayne	NK - 16- 9	Iron River	NL - 16- 4
Davenport	NK - 15- 9	Indianapolis	NJ - 16- 2	Manitowac	NL - 16-11
Decatur	NJ - 16- 1	Louisville	NJ - 16- 6	Marquette	NL - 16- 5
Dubuque	NK - 15- 6	Muncie	NK - 16-12	Midland	NK - 16- 3
Evansville	NJ - 16- 8	Paducah	NJ - 16- 7	Milwaukee	NK - 16- 2
Indianapolis	NJ - 16- 2	Vincennes	NJ - 16- 5	Racine	NK - 16- 5
Paducah	NJ - 16- 7			Tawas City	NL - 17- 7
Peoria	NK - 16-10	Michigan		Toledo	NK - 17- 7
Quincy	NJ - 15- 3	Alpena	NL - 17- 4	Traverse City	NL - 16-12
Racine	NK - 16- 5	Ashland	NL - 15- 6		
Rockford	NK - 16- 4	Chicago	NK - 16- 8	Minnesota	
Rolla	NJ - 15- 9	Detroit	NK - 17- 4	Ashland	NL - 15- 6
St. Louis	NJ - 15- 6	Escanaba	NL - 16- 8	Bemidji	NL - 15- 1
Vincennes	NJ - 16- 5	Flint	NK - 17- 1	Brainerd	NL - 15- 4

Region 4 (cont'd)
United States Geological Survey and Army Map Service Quadrangles

1:250,000 Scale

STATES WITHIN REGION

QUADRANGLE NAME	QUADRANGLE NUMBER
Minnesota (cont'd)	
Duluth	NL - 15- 5
Eau Claire	NL - 15-12
Fairmont	NK - 15- 1
Fargo	NL - 14- 6
Ft. William	NM - 16-10
Grand Forks	NL - 14- 3
Hancock	NL - 16- 1
Hibbing	NL - 15- 2
International Falls	NM - 15-11
Kenora	NM - 15- 7
La Crosse	NK - 15- 3
Mason City	NK - 15- 2
Milbank	NL - 14- 9
New Ulm	NL - 15-10
Quatico	NM - 15-12
Roseau	NM - 15-10
Sioux Falls	NK - 14- 3
Stillwater	NL - 15- 8
St. Cloud	NL - 15- 7
St. Paul	NL - 15-11
Thief River Falls	NM - 14-12
Two Harbors	NL - 15- 3
Watertown	NL - 14-12
Wisconsin	
Ashland	NL - 15- 6
Dubuque	NK - 15- 6
Duluth	NL - 15- 5
Eau Claire	NL - 15-12
Green Bay	NL - 16-10
Hancock	NL - 16- 1
Iron River	NL - 16- 4
La Crosse	NK - 15- 3
Madison	NK - 16- 1
Manitowac	NL - 16-11
Milwaukee	NK - 16- 2
Racine	NK - 16- 5
Ricewake	NL - 15- 9
Rockford	NK - 16- 4
Stillwater	NL - 15- 8
St. Paul	NL - 15-11
Two Harbors	NL - 15- 3



Schematic Illustration of
United States Geological Survey
And Army Map Service Quadrangles
1:250,000 Scale

O.C.D.M.

REGION 5

Region 5
United States Geological Survey and Army Map Service Quadrangles

1:250,000 Scale

REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Abilene	NL - 14-11	El Paso	NH - 13- 1	Perryton	NJ - 14-10
Albuquerque	NI - 13- 1	Enid	NJ - 14-12	Plainview	NI - 14- 4
Alexandria	NH - 15- 2	Fort Smith	NI - 15- 1	Poplar Bluff	NJ - 15-12
Amarillo	NI - 14- 1	Fort Stockton	NH - 13- 6	Port Arthur	NH - 15- 8
Ardmore	NI - 14- 6	Fort Sumner	NI - 13- 5	Presidio	NH - 13- 8
Austin	NH - 14- 6	Gallup	NI - 12- 3	Raton	NJ - 13-11
Aztec	NJ - 13-10	Greenwood	NI - 15- 9	Roswell	NI - 13- 8
Baton Rouge	NH - 15- 6	Harrison	NJ - 15-11	Russellville	NI - 15- 2
Bay City	NH - 15-10	Helena	NK - 15- 6	San Angelo	NH - 14- 1
Beaumont	NH - 15- 4	Hobbs	NI - 13-12	San Antonio	NH - 14- 8
Big Springs	NI - 14-10	Houston	NH - 15- 7	Santa Fe	NI - 13- 2
Blytheville	NI - 16- 1	Jackson	NI - 15-12	Sequin	NH - 14- 9
Boquilias	NH - 13- 9	Lake Charles	NH - 15- 5	Sherman	NI - 14- 9
Breton Sound	NH - 16- 7	Laredo	NG - 14- 2	Shiprock	NJ - 12-12
Brown Field	NI - 13- 9	Las Cruces	NI - 13-10	Shreveport	NI - 15-11
Brownsville	NG - 14-6,9	Lawton	NI - 14- 5	Silver City	NI - 12-12
Brownwood	NH - 14- 2	Little Rock	NI - 15- 5	Socorro	NI - 13- 4
Carlsbad	NI - 13-11	Llano	NH - 14- 5	Sonora	NH - 14- 4
Clifton	NJ - 12- 9	Lubbock	NI - 14- 7	St. Johns	NI - 12- 6
Clinton	NI - 14- 2	Marfa	NH - 13- 5	Texarkana	NK - 15- 7
Clovis	NI - 13- 6	McAlester	NI - 15- 4	Tucumcari	NI - 13- 3
Corpus Christi	NH - 14- 3	McAllen	NG - 14- 5	Tularosa	NI - 13- 7
Crystal City	NH - 14-11	Memphis	NI - 15- 3	Tulsa	NJ - 15-10
Dalhart	NJ - 13-12	Mobile	NH - 16- 4	Tyler	NI - 15-10
Dallas	NI - 14-12	Natchez	NH - 15- 3	Van Horn	NH - 13- 2
Del Rio	NH - 14- 7	New Orleans	NH - 15- 9	Victoria	NH - 14-12
Douglas (Bisbee)	NH - 12- 3	Oklahoma City	NI - 14- 3	Waco	NH - 14- 3
Eagle Pass	NH - 14-10	Palestine	NH - 15- 1	Wichita Falls	NI - 14- 8
El Dorado	NI - 15- 8	Pecos	NH - 13- 3	Woodward	NJ - 14-11

STATES WITHIN REGION

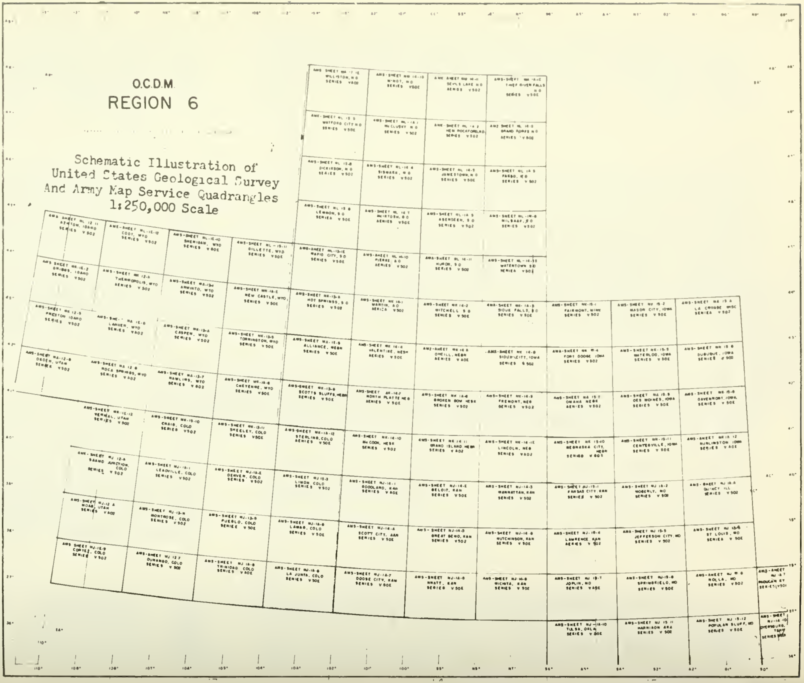
QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Arkansas		Louisiana		New Mexico	
Blytheville	NI - 16- 1	Alexandria	NH - 15- 2	Albuquerque	NI - 13- 1
Dyersburg	NJ - 16-10	Baton Rouge	NH - 15- 6	Aztec	NJ - 13-10
El Dorado	NI - 15- 8	Breton Sound	NH - 16- 7	Brownfield	NI - 13- 9
Ft. Smith	NI - 15- 1	Greenwood	NI - 15- 9	Carlsbad	NI - 13-11
Greenwood	NI - 15- 9	Jackson	NI - 15-12	Clifton	NI - 12- 9
Harrison	NJ - 15-11	Lake Charles	NH - 15- 5	Clovis	NI - 13- 6
Helena	NI - 15- 6	Mobile	NH - 16- 4	Dalhart	NI - 13-12
Little Rock	NI - 15- 5	Natchez	NH - 15- 3	Douglas	
McAlester	NI - 15- 4	New Orleans	NH - 15- 9	(Bisbee)	NH - 12- 3
Memphis	NI - 15- 3	Palestine	NH - 15- 1	El Paso	NH - 13- 1
Poplar Bluff	NJ - 15-12	Port Arthur	NH - 15- 8	Fort Sumner	NI - 13- 5
Russellville	NI - 15- 2	Shreveport	NI - 15-11	Gallup	NI - 12- 3
Texarkana	NI - 15- 7	Texarkana	NI - 15- 7	Hobbs	NI - 13-12
Tulsa	NJ - 15-10	Tyler	NI - 15-10	Las Cruces	NI - 13-10

Region 5 (cont'd)
United States Geological Survey and Army Map Service Quadrangles

1:250,000 Scale

STATES WITHIN REGION

QUADRANGLE NAME	QUADRANGLE NUMBER
New Mexico (cont'd)	
Pecos	NH - 13- 3
Raton	NJ - 13-11
Roswell	NI - 13- 8
Santa Fe	NI - 13- 2
St. Johns	NI - 12- 6
Shiprock	NJ - 12-12
Silver City	NI - 12-12
Soccorro	NI - 13- 4
Tucumcari	NI - 13- 3
Tularosa	NI - 13- 7
Van Horn	NH - 13- 2
Oklahoma	
Ardmore	NI - 14- 6
Clinton	NI - 14- 2
Dalhart	NJ - 13-12
Enid	NJ - 14-12
Fort Smith	NI - 15- 1
Lawton	NI - 14- 5
McAlester	NI - 15- 4
Oklahoma City	NI - 14- 3
Perrytown	NJ - 14-10
Sherman	NI - 14- 9
Texarkana	NI - 15- 7
Tulsa	NJ - 15-10
Wichita Falls	NI - 14- 8
Woodward	NJ - 14-11
Texas	
Abilene	NI - 14-11
Alexandria	NH - 15- 2
Amarillo	NI - 14- 1
Austin	NH - 14- 6
Bay City	NH - 15-10
Beaumont	NH - 15- 4
Big Spring	NI - 14-10
Boquilias	NH - 13- 9
Brownfield	NI - 13- 9
Brownsville	NG - 16-6,9
Brownwood	NH - 14- 2
Carlsbad	NI - 13-11
Clovis	NI - 13- 6
Corpus Christi	NG - 14- 3
Crystal City	NH - 14-11
Dalhart	NJ - 13-12
Dallas	NI - 14-12
Texas (cont'd)	
Del Rio	NH - 14- 7
Eagle Pass	NH - 14-10
El Paso	NH - 13- 1
Ft. Stockton	NH - 13- 6
Hobbs	NI - 13-12
Houston	NH - 15- 7
Lake Charles	NH - 15- 5
Laredo	NG - 14- 2
Las Cruces	NI - 13-10
Lawton	NI - 14- 5
Llano	NH - 14- 5
Lubbock	NI - 14- 7
Marfa	NH - 13- 5
McAllen	NG - 14- 5
Palestine	NH - 15- 1
Pecos	NH - 13- 3
Perryton	NJ - 14-10
Plainview	NI - 14- 4
Port Arthur	NH - 15- 8
Presidio	NH - 13- 8
San Angelo	NH - 14- 1
San Antonio	NH - 14- 8
Sequin	NH - 14- 9
Sherman	NI - 14- 9
Shreveport	NI - 15-11
Sonora	NH - 14- 4
Texarkana	NI - 15- 7
Tucumcari	NI - 13- 3
Tyler	NI - 15-10
Van Horn	NH - 13- 2
Victoria	NH - 14-12
Waco	NH - 14- 3
Wichita Falls	NI - 14- 8



O.C.D.M.

REGION 6

Schematic Illustration of United States Geological Survey And Army Map Service Quadrangles 1:250,000 Scale

Region 6
United States Geological Survey and Army Map Service Quadrangles

1:250,000 Scale

REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Aberdeen	NL - 14- 8	Grand Junction	NJ - 12- 3	New Ulm	NL - 15-10
Alliance	NK - 13- 6	Great Bend	NJ - 14- 5	North Platte	NK - 14- 7
Arminto	NK - 13- 1	Greely	NK - 13-11	Ogden	NK - 12- 8
Ashland	NL - 15- 6	Hancock	NL - 16- 1	Omaha	NK - 15- 7
Ashton	NL - 12-11	Hibbing	NL - 15- 2	O'Neill	NK - 14-12
Beloit	NJ - 14- 2	Hot Springs	NK - 13- 3	Pierre	NL - 14-10
Bemidji	NL - 15- 1	Huron	NL - 14-11	Pratt	NJ - 14- 8
Bismark	NL - 14- 4	Hutchinson	NJ - 14- 6	Preston	NK - 12- 5
Brainerd	NL - 15- 4	International Falls	NM - 15-11	Pueblo	NJ - 13- 5
Broken Bow	NK - 14- 8	Jamestown	NL - 14- 5	Quatico	NM - 15-12
Burlington	NK - 15-12	Joplin	NJ - 15- 7	Rapid City	NL - 13-12
Casper	NK - 13- 4	Kansas City	NJ - 15- 1	Rawlings	NK - 13- 7
Centerville	NK - 15-11	Kenora	NM - 15- 7	Hot Springs	NK - 12- 9
Cheyenne	NK - 13- 8	La Crosse	NK - 15- 3	Roseau	NM - 15-10
Cody	NL - 12-12	La Junta	NJ - 13- 9	Santa Cruz	NJ - 10-12
Cortez	NJ - 12- 9	Lamor	NJ - 13- 6	Scott City	NJ - 14- 4
Craig	NK - 13-10	Lander	NK - 12- 6	Scotts Bluff	NK - 13- 9
Davenport	NK - 15- 9	Lawrence	NJ - 15- 4	Sheridan	NL - 13-10
Denver	NJ - 13- 2	Leadville	NJ - 13- 1	Sioux City	NK - 14- 6
Des Moines	NK - 15- 8	Lemmon	NL - 13- 9	Sioux Falls	NK - 14- 3
Devis's Lake	NM - 14-11	Limon	NJ - 13- 3	Sterling	NK - 13-12
Dickinson	NL - 13- 6	Lincoln	NK - 14- 2	Stillwater	NL - 15- 8
Dodge City	NJ - 14- 7	Manhattan	NJ - 14- 3	St. Cloud	NL - 15- 7
Driggs	NK - 12- 2	Martin	NK - 14- 1	St. Paul	NL - 15-11
Dubuque	NK - 15- 6	Mason City	NK - 15- 2	Thermopolis	NK - 12- 3
Duluth	NL - 15- 5	McClusky	NL - 14- 1	Thief River Falls	NM - 14-12
Durango	NJ - 13- 7	McCook	NK - 14-10	Torrington	NK - 13- 5
Eau Clair	NL - 15-12	McIntosh	NL - 14- 7	Trinidad	NJ - 13- 8
Fairmont	NK - 15- 1	Milbank	NL - 14- 9	Two Harbors	NL - 15- 3
Fargo	NL - 14- 6	Minot	NM - 14-10	Valentine	NK - 14- 4
Fort Dodge	NK - 15- 4	Mitchell	NK - 14- 2	Vernal	NK - 12-12
Fort Williams	NM - 16-10	Moab (Delta)	NJ - 12- 6	Waterford City	NL - 13- 3
Fremont	NK - 14- 9	Montrose	NJ - 13- 4	Waterloo	NK - 15- 5
Gillette	NL - 13-11	Nebraska City	NK - 15-10	Watertown	NL - 14-12
Goodland	NJ - 14- 1	New Castle	NK - 13- 2	Wichita	NJ - 14- 9
Grand Forks	NL - 14- 3	New Rockford	NL - 14- 2	Williston	NM - 13-12
Grand Island	NK - 14-11				

Region 6 (cont'd)
United States Geological Survey and
Army Map Service Quadrangles

1:250,000 Scale

STATES WITHIN REGION

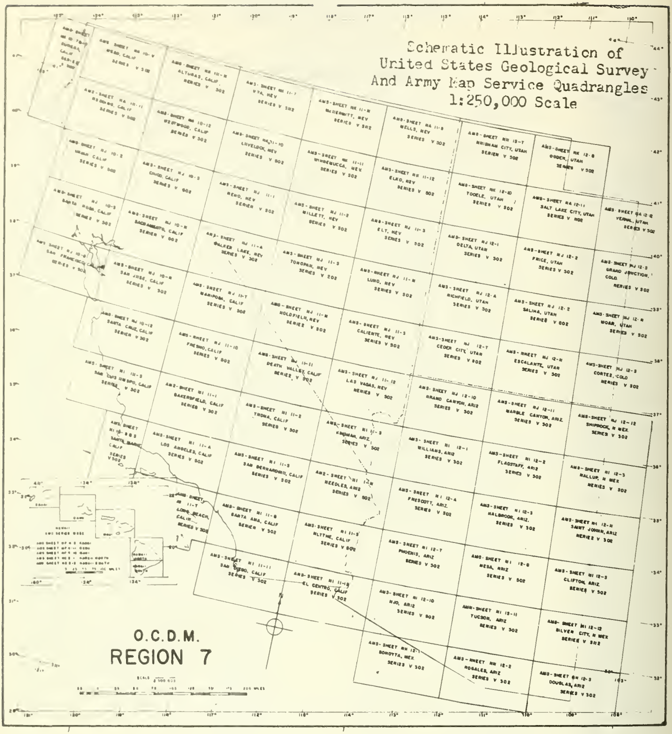
QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Colorado		Kansas (cont'd)		Nebraska (cont'd)	
Aztec	NJ - 13-10	Goodland	NJ - 14- 1	Scotts Bluff	NK - 13- 9
Cheyenne	NK - 13- 8	Hutchinson	NJ - 14- 6	Sioux City	NK - 14- 6
Cortez	NJ - 12- 9	Joplin	NJ - 15- 7	Torrington	NK - 13- 5
Craig	NK - 13-10	Kansas City	NJ - 15- 1	Valentine	NK - 14- 4
Dalhart	NJ - 13-12	Lawrence	NJ - 15- 4		
Denver	NJ - 13- 2	Manhattan	NJ - 14- 3	North Dakota	
Durango	NJ - 13- 7	McCook	NK - 14-10	Aberdeen	NL - 14- 8
Grand Junction	NJ - 12- 3	Perrytown	NJ - 14-10	Bismarck	NL - 14- 4
Greely	NK - 13-11	Pratt	NJ - 14- 8	Devils Lake	NM - 14-11
La Junta	NJ - 13- 9	Scott City	NJ - 14- 4	Dickinson	NL - 13- 6
Lamar	NJ - 13- 6	Wichita	NJ - 14- 9	Ekalaka	NL - 13- 6
Leadville	NJ - 13- 1			Fargo	NL - 14- 6
Limon	NJ - 13- 3	Missouri		Glendive	NL - 13- 2
Moab (Delta)	NJ - 12- 6	Belleville	NJ - 16- 4	Grand Forks	NL - 14- 3
Montrose	NJ - 13- 4	Blytheville	NI - 16- 1	Jamestown	NL - 14- 5
Pueblo	NJ - 13- 5	Burlington	NK - 15-12	Lemmon	NL - 13- 9
Raton	NJ - 13-11	Centerville	NK - 15-11	McClusky	NL - 14- 1
Rawlings	NK - 13- 7	Dyersburg	NJ - 16-10	Miles City	NL - 13- 5
Rock Springs	NK - 12- 9	Harrison	NJ - 15- 1	Minot	NM - 14-10
Sterling	NK - 13-12	Jefferson	NJ - 15- 5	New Rockford	NL - 14- 2
Trinidad	NJ - 13- 8	Joplin	NJ - 15- 7	Thief River Falls	NM - 14-12
Vernal	NK - 12-12	Kansas City	NJ - 15- 1	Watford City	NL - 13- 3
		Lawrence	NJ - 15- 4	Williston	NM - 13-12
Iowa		Memphis	NI - 15- 3	Wolfpoint	NM - 13-11
Burlington	NK - 15-12	Moberly	NJ - 15- 2		
Centerville	NK - 15-11	Nebraska City	NK - 15-10	South Dakota	
Davenport	NK - 15- 9	Paducah	NJ - 16- 7	Aberdeen	NL - 14- 8
Des Moines	NK - 15- 8	Poplar Bluff	NJ - 15-12	Ekalaka	NL - 13- 8
Dubuque	NK - 15- 6	Quincy	NJ - 15- 3	Gillette	NL - 13-11
Fairmont	NK - 15- 1	Rolla	NJ - 15- 9	Hot Springs	NK - 13- 3
Freemont	NK - 14- 9	Springfield	NJ - 15- 8	Huron	NL - 14-11
Ft. Dodge	NK - 15- 4	St. Louis	NJ - 15- 6	Lemmon	NL - 13- 9
La Crosse	NK - 15- 3	Tulsa	NJ - 15-10	Martin	NK - 14- 1
Mason City	NK - 15- 2			McIntosh	NL - 14- 7
Nebraska City	NK - 15-10	Nebraska		Milbank	NL - 14- 9
Omaha	NK - 15- 7	Alliance	NK - 13- 6	Mitchell	NK - 14- 2
Sioux City	NK - 14- 6	Broken Bow	NK - 14- 8	New Castle	NK - 13- 2
Sioux Falls	NK - 14- 3	Cheyenne	NK - 13- 8	Pierre	NL - 14-10
Waterloo	NK - 15- 5	Fremont	NK - 14- 9	Rapid City	NL - 13-12
		Grand Island	NK - 14-11	Sioux City	NK - 14- 6
Kansas		Lincoln	NK - 14- 2	Sioux Falls	NK - 14- 3
Beloit	NJ - 14- 2	McCook	NK - 14-10	Watertown	NL - 14-12
Dalhart	NJ - 13-12	Nebraska City	NK - 15-10		
Dodge City	NJ - 14- 7	North Platte	NK - 14- 7		
Grand Island	NK - 14-11	Omaha	NK - 15- 7		
Great Bend	NJ - 14- 5	O'Neill	NK - 14-12		

Region 6 (cont'd)
United States Geological Survey and Army Map Service Quadrangles

1:250,000 Scale

STATES WITHIN REGION

QUADRANGLE NAME	QUADRANGLE NUMBER
Wyoming	
Armito	NK - 13- 1
Ashton	NL - 12-11
Billings	NL - 12- 9
Casper	NK - 13- 4
Cheyenne	NK - 13- 8
Cody	NL - 12-12
Driggs	NK - 12- 2
Gillette	NL - 13-11
Hardin	NL - 13- 7
Lander	NK - 12- 6
New Castle	NK - 13- 2
Ogden	NK - 12- 8
Preston	NK - 12- 5
Rawlings	NK - 13- 7
Rock Springs	NK - 12- 9
Sheridan	NL - 13-10
Thermopolis	NK - 12- 3
Torrington	NK - 13- 5



Schematic Illustration of United States Geological Survey And Army Map Service Quadrangles 1:250,000 Scale

O.C.D.M. REGION 7

AMS-SHEET NK 10-8 WEAD, CALIF SERIES V 502
AMS-SHEET NK 10-9 ALTURAS, CALIF SERIES V 502
AMS-SHEET NK 11-7 VYA, NEV SERIES V 502
AMS-SHEET NK 11-8 McDERMITT, NEV SERIES V 502
AMS-SHEET NK 11-9 WELLS, NEV SERIES V 502
AMS-SHEET NK 12-7 BRIGHAM CITY, UTAH SERIES V 502
AMS-SHEET NK 12-8 OGDEN, UTAH SERIES V 502
AMS-SHEET NK 10-11 REDDING, CALIF SERIES V 502
AMS-SHEET NK 10-12 WESTWOOD, CALIF SERIES V 502
AMS-SHEET NK 11-10 LOVELOCK, NEV SERIES V 502
AMS-SHEET NK 11-11 WINNEMUCCA, NEV SERIES V 502
AMS-SHEET NK 11-12 ELKO, NEV SERIES V 502
AMS-SHEET NK 12-10 TOOELE, UTAH SERIES V 502
AMS-SHEET NK 12-11 SALT LAKE CITY, UTAH SERIES V 502
AMS-SHEET NK 12-12 VERNAL, UTAH SERIES V 502
AMS-SHEET NJ 10-2 UKIAH, CALIF SERIES V 502
AMS-SHEET NJ 10-3 CHICO, CALIF SERIES V 502
AMS-SHEET NJ 11-1 RENO, NEV SERIES V 502
AMS-SHEET NJ 11-2 MILLETT, NEV SERIES V 502
AMS-SHEET NJ 11-3 ELY, NEV SERIES V 502
AMS-SHEET NJ 12-1 DELTA, UTAH SERIES V 502
AMS-SHEET NJ 12-2 PRICE, UTAH SERIES V 502
AMS-SHEET NJ 12-3 GRAND JUNCTION, COLO. SERIES V 502
AMS-SHEET NJ 10-5 SANTA ROSA, CALIF SERIES V 502
AMS-SHEET NJ 10-6 SACRAMENTO, CALIF SERIES V 502
AMS-SHEET NJ 11-4 WALKER LAKE, NEV SERIES V 502
AMS-SHEET NJ 11-5 TONOPAH, NEV SERIES V 502
AMS-SHEET NJ 11-6 LUND, NEV SERIES V 502
AMS-SHEET NJ 12-4 RICHFIELD, UTAH SERIES V 502
AMS-SHEET NJ 12-5 SALINA, UTAH SERIES V 502
AMS-SHEET NJ 12-6 MOAB, UTAH SERIES V 502
AMS-SHEET NJ 10-8 SAN FRANCISCO, CALIF SERIES V 502
AMS-SHEET NJ 10-9 SAN JOSE, CALIF SERIES V 502
AMS-SHEET NJ 11-7 MARIPOSA, CALIF SERIES V 502
AMS-SHEET NJ 11-8 GOLDFIELD, NEV SERIES V 502
AMS-SHEET NJ 11-9 CALIENTE, NEV SERIES V 502
AMS-SHEET NJ 12-7 CEDAR CITY, UTAH SERIES V 502
AMS-SHEET NJ 12-8 ESCALANTE, UTAH SERIES V 502
AMS-SHEET NJ 12-9 CORTEZ, COLO SERIES V 502
AMS-SHEET NJ 10-12 SANTA CRUZ, CALIF SERIES V 502
AMS-SHEET NJ 11-10 FRESNO, CALIF SERIES V 502
AMS-SHEET NJ 11-11 DEATH VALLEY, CALIF SERIES V 502
AMS-SHEET NJ 11-12 LAS VEGAS, NEV SERIES V 502
AMS-SHEET NJ 12-10 GRAND CANYON, ARIZ SERIES V 502
AMS-SHEET NJ 12-11 MARBLE CANYON, ARIZ SERIES V 502
AMS-SHEET NJ 12-12 SHIPROCK, N MEX SERIES V 502
AMS-SHEET NI 10-3 SAN LUIS OBISPO, CALIF SERIES V 502
AMS-SHEET NI 11-1 BAKERSFIELD, CALIF SERIES V 502
AMS-SHEET NI 11-2 TRONA, CALIF SERIES V 502
AMS-SHEET NI 11-3 KINGMAN, ARIZ SERIES V 502
AMS-SHEET NI 12-1 WILLIAMS, ARIZ SERIES V 502
AMS-SHEET NI 12-2 FLAGSTAFF, ARIZ SERIES V 502
AMS-SHEET NI 12-3 GALLUP, N MEX SERIES V 502
AMS-SHEET NI 10-6 SANTA MARIA, CALIF SERIES V 502
AMS-SHEET NI 11-4 LOS ANGELES, CALIF SERIES V 502
AMS-SHEET NI 11-5 SAN BERNARDINO, CALIF SERIES V 502
AMS-SHEET NI 11-6 NEEDLES, ARIZ SERIES V 502
AMS-SHEET NI 12-4 PRESCOTT, ARIZ SERIES V 502
AMS-SHEET NI 12-5 HOLBROOK, ARIZ SERIES V 502
AMS-SHEET NI 12-6 SAINT JOHNS, ARIZ SERIES V 502
AMS-SHEET NI 11-7 LONG BEACH, CALIF SERIES V 502
AMS-SHEET NI 11-8 SANTA ANA, CALIF SERIES V 502
AMS-SHEET NI 11-9 BLYTHE, CALIF SERIES V 502
AMS-SHEET NI 12-7 PHOENIX, ARIZ SERIES V 502
AMS-SHEET NI 12-8 MESA, ARIZ SERIES V 502
AMS-SHEET NI 12-9 CLIFTON, ARIZ SERIES V 502
AMS-SHEET NI 11-11 SAN DIEGO, CALIF SERIES V 502
AMS-SHEET NI 11-12 EL CENTRO, CALIF SERIES V 502
AMS-SHEET NI 12-10 AJO, ARIZ SERIES V 502
AMS-SHEET NI 12-11 TUCSON, ARIZ SERIES V 502
AMS-SHEET NI 12-12 SILVER CITY, N MEX SERIES V 502
AMS-SHEET NH 12-1 SONOYTA, MEX SERIES V 502
AMS-SHEET NH 12-2 NOGALES, ARIZ SERIES V 502
AMS-SHEET NH 12-3 DOUGLAS, ARIZ SERIES V 502

Region 7
United States Geological Survey and Army Map Service Quadrangles

1:250,000 Scale

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Ajo	NI - 12-10	Kingman	NI - 11- 3	San Bernardino	NI - 11- 5
Alturas	NK - 10- 9	Las Vegas	NJ - 11-12	San Diego	NI - 11-11
Austin	NJ - 11- 2	Long Beach	NI - 11- 7	San Francisco	NJ - 10- 8
Bakersfield	NI - 11- 1	Los Angeles	NI - 11- 4	San Jose	NJ - 10- 9
Brigham City	NK - 12- 7	Lovelock	NK - 11-10	San Luis Obispo	NI - 10- 3
Caliente	NJ - 11- 9	Lund	NJ - 11- 6	Santa Ana	NI - 11- 8
Cedar City	NJ - 12- 7	Marble Canyon	NJ - 12-11	Santa Cruz	NJ - 10-12
Chico	NJ - 10- 3	Mariposa	NJ - 11- 7	Santa Maria	NI - 10-6,9
Clifton	NI - 12- 9	McDermitt	NK - 11- 8	Santa Rosa	NJ - 10- 5
Cortez	NJ - 12- 9	Medford	NK - 10- 5	Shiprock	NJ - 12-12
Death Valley	NJ - 11-11	Mesa	NI - 12- 8	Silver City	NI - 12-12
Delta	NJ - 12- 1	Moab (Delta)	NJ - 12- 6	Sonoyta	NH - 12- 1
Douglas (Bisbee)	NH - 12- 3	Needles	NI - 11- 6	St. Johns	NI - 12- 6
El Centro	NI - 11-12	Nogales	NH - 12- 2	Tonopah	NJ - 11- 5
Elko	NK - 11-12	Ogden	NK - 12- 8	Tooele	NK - 12-10
Ely	NJ - 11- 3	Phoenix	NI - 12- 7	Trona	NI - 11- 2
Escalante	NJ - 12- 8	Prescott	NI - 12- 4	Tucson	NI - 12-11
Eureka	NK - 10-7,10	Price	NJ - 12- 2	Vernal	NK - 12-12
Flagstaff	NI - 12- 2	Redding	NK - 10-11	Vya	NK - 11- 7
Fort Bragg	NJ - 10- 2	Reno	NJ - 11- 1	Walker Lake	NJ - 11- 4
Fresno	NJ - 11-10	Richfield	NJ - 12- 4	Weed	NK - 10- 8
Gallup	NI - 12- 3	Sacramento	NJ - 10- 6	Wells	NK - 11- 9
Goldfield	NJ - 11- 8	Salina	NJ - 12- 5	Westwood	NK - 10-12
Grand Canyon	NJ - 12-10	Salt Lake City	NK - 12-11	Williams	NI - 12- 1
Grand Junction	NJ - 12- 3	Salton Sea	NI - 11- 9	Winnemucca	NK - 11-11
Holbrook	NI - 12- 5				

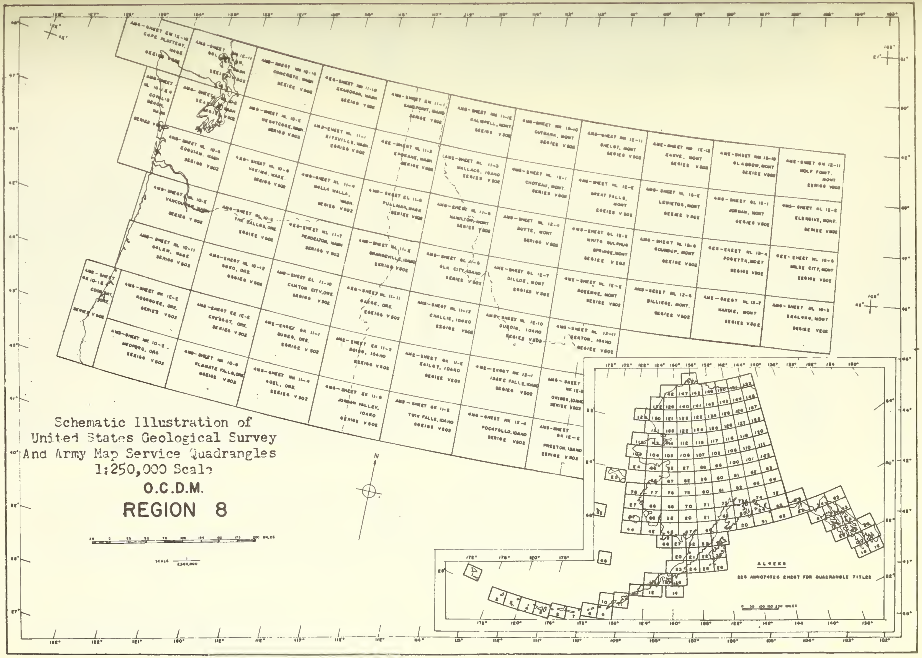
STATES WITHIN REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Arizona		Arizona (cont'd)		California (cont'd)	
Ajo	NI - 12-10	Salton Sea	NI - 11- 9	Fresno	NJ - 11-10
Clifton	NI - 12- 9	Shiprock	NJ - 12-12	Goldfield	NJ - 11- 8
Douglas	NH - 12- 3	Silver City	NI - 12-12	Kingman	NI - 11- 3
El Centro	NI - 11-12	Sonoyta	NH - 12- 1	Long Beach	NI - 11- 7
Flagstaff	NI - 12- 2	St. Johns	NI - 12- 6	Los Angeles	NI - 11- 4
Gallup	NI - 12- 3	Tucson	NI - 12-11	Mariposa	NJ - 11- 7
Grand Canyon	NJ - 12-10	Williams	NI - 12- 1	Medford	NK - 10- 5
Holbrook	NI - 12- 5			Needles	NI - 11- 6
Kingman	NI - 11- 3	California		Redding	NK - 10-11
Las Vegas	NJ - 11-12	Alturas	NK - 10- 9	Sacramento	NJ - 10- 6
Marble Canyon	NJ - 11-12	Bakersfield	NF - 11- 1	Salton Sea	NI - 11- 9
Mesa	NI - 12- 8	Chico	NJ - 10- 3	San Bernardino	NI - 11- 5
Needles	NI - 11- 6	Death Valley	NJ - 11-11	San Diego	NI - 11-11
Nogales	NH - 12- 2	El Centro	NI - 11-12	San Jose	NJ - 10- 9
Phoenix	NI - 12- 7	Eureka	NK - 10-7,10	San Francisco	NJ - 10- 8
Prescott	NI - 12- 4	Ft. Bragg	NJ - 10- 2	San Luis Obispo	NI - 10- 3

Region 7 (cont'd)
United States Geological Survey and Army Map Service Quadrangles

1:250,000 Scale

QUADRANGLE NAME	QUADRANGLE NUMBER
California (cont'd)	
Santa Ana	NI - 11- 8
Santa Cruz	NJ - 10-12
Santa Maria	NI - 10-6,9
Santa Rosa	NJ - 10- 5
Trona	NI - 11- 2
Walker Lake	NJ - 11- 4
Weed	NK - 10- 8
Westwood	NK - 10-12
Nevada	
Austin	NJ - 11- 2
Caliente	NJ - 11- 9
Death Valley	NJ - 11-11
Elko	NK - 11-12
Ely	NJ - 11- 3
Goldfield	NJ - 11- 8
Kingman	NI - 11- 3
Las Vegas	NJ - 11-12
Lovelock	NK - 11-10
Lund	NJ - 11- 6
Mariposa	NJ - 11- 7
McDermitt	NK - 11- 8
Reno	NJ - 11- 1
Tonapah	NJ - 11- 5
Vya	NK - 11- 7
Walker Lake	NJ - 11- 4
Wells	NK - 11- 9
Winnemucca	NK - 11-11
Utah	
Brigham City	NK - 12- 7
Cedar City	NJ - 12- 7
Cortez	NJ - 12- 9
Delta	NJ - 12- 1
Escalante	NJ - 12- 8
Grand Junction	NJ - 12- 3
Moab (Delta)	NJ - 12- 6
Ogden	NK - 12- 8
Price	NJ - 12- 2
Richfield	NJ - 12- 4
Salina	NJ - 12- 5
Salt Lake City	NK - 12-11
Tooele	NK - 12-10
Vernal	NK - 12-12



Schematic Illustration of
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REGION 8

Region 8
United States Geological Survey and Army Map Service Quadrangles

1:250,000 Scale

REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Adel	NK - 11- 4	Dillon	NL - 12- 7	Miles City	NL - 13- 5
Ashton	NL - 12-11	Driggs	NK - 12- 2	Okanogan	NM - 11-10
Bailey	NL - 11-11	Dubois	NL - 12-10	Pendleton	NL - 11- 7
Baker	NM - 10-10	Ekalaka	NL - 13- 8	Pocatello	NK - 12- 4
Bellingham	NL - 10-12	Forsyth	NL - 13- 4	Preston	NK - 12- 5
Bend	NL - 12- 9	Gillette	NL - 13-11	Ritzville	NL - 11- 1
Billings	NK - 11- 2	Glasgow	NM - 13-10	Roseburg	NK - 10- 2
Boise	NL - 12- 8	Glendive	NL - 13- 2	Roundup	NL - 12- 6
Bozeman	NL - 12- 8	Grangeville	NL - 11- 8	Salem	NL - 10-11
Brigham City	NK - 12- 7	Great Falls	NL - 12- 2	Sandpoint	NM - 11-11
Burns	NK - 11- 1	Hamilton	NL - 11- 6	Seattle	NL - 10- 2
Butte	NL - 12- 4	Hardin	NL - 13- 7	Shelby	NM - 12-11
Canyon City	NL - 11-10	Havre	NM - 12- 2	Spokane	NL - 11- 2
Cape Flattery	NM - 10-11	Hoquiam	NL - 10- 5	The Dalles	NL - 10- 9
Challis	NL - 11-12	Idaho Falls	NK - 12- 1	Twin Falls	NK - 11- 6
Chateau	NL - 12- 1	Jordon	NL - 13- 1	Vancouver	NL - 10- 8
Concrete	NM - 10-12	Jordon Valley	NK - 11- 5	Walla Walla	NL - 11- 4
Coos Bay	NK - 10-1,4	Kalispell	NM - 11-12	Wallace	NL - 11- 3
Copalis Beach	NL - 10-1,4	Klamath Falls	NK - 10- 6	Wenatchee	NL - 10- 3
Crescent Lake	NK - 10- 3	Lewiston	NL - 11- 5	White Sulphur Springs	NL - 12- 5
Cut Bank	NM - 12-10	Lewistown	NL - 12- 3	Wolf Point	NM - 13-11
Czizek	NL - 11- 9	Medford	NK - 10- 5	Yakima	NL - 10- 6

STATES WITHIN REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Idaho		Montana		Montana (cont'd)	
Ashton	NL - 12-11	Ashton	NL - 12-11	Shelby	NM - 12-11
Bailey	NK - 11- 3	Billings	NL - 12- 9	Wallace	NL - 11- 3
Baker	NL - 11-11	Bozeman	NL - 12- 8	White Sulphur Springs	NL - 11- 3
Boise	NK - 11- 2	Butte	NL - 12- 4	Wolf Point	NM - 13-11
Brigham City	NK - 12- 7	Chateau	NL - 12- 1		
Challis	NL - 11-12	Cutbank	NM - 12-10	Oregon	
Czcizek	NL - 11- 9	Czizek	NL - 11- 9	Adel	NK - 11- 4
Dillon	NI - 12- 7	Dillon	NL - 12- 7	Baker	NL - 11-11
Driggs	NK - 12- 2	Dubois	NL - 12-10	Bend	NL - 10-12
Dubois	NL - 12-10	Ekalaka	NL - 13- 8	Boise	NK - 11- 2
Grangeville	NL - 11- 8	Forsyth	NL - 13- 4	Burns	NK - 11- 1
Hamilton	NL - 11- 6	Gillette	NL - 13-11	Canyon City	NL - 11-10
Idaho Falls	NK - 12- 1	Glasgow	NM - 13-10	Coos Bay	NK - 10-1,4
Jordon Valley	NK - 11- 5	Glendive	NL - 13- 2	Crescent Lake	NK - 10- 3
Lewiston	NL - 11- 5	Great Falls	NL - 13- 2	Grangeville	NL - 11- 8
Pocatello	NK - 12- 4	Hamilton	NL - 12- 6	Hoquiam	NL - 10- 5
Preston	NK - 12- 5	Hardin	NL - 13- 7	Jordon Valley	NK - 11- 5
Sandpoint	NM - 11-11	Harve	NM - 12-12	Klamath Falls	NK - 10- 6
Spokane	NL - 11- 2	Jordan	NL - 13- 1	Lewiston	NL - 11- 5
Twin Falls	NK - 11- 6	Kalispell	NM - 11-12	Medford	NK - 10- 5
Wallace	NL - 11- 3	Lewistown	NL - 12- 3	Pendleton	NL - 11- 7
		Miles City	NL - 13- 5	Roseburg	NK - 10- 2
		Roundup	NL - 12- 6	Salem	NL - 10-11

Region 8 (cont'd)
United States Geological Survey and
Army Map Service Quadrangles

1:250,000 Scale

STATES WITHIN REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Oregon (cont'd)		Alaska (cont'd)		Alaska (cont'd)	
The Dalles	NL - 10- 9	Black River	NQ - 7,8- 5	Ketchikan	NN - 9- 1
Vancouver	NL - 10- 8	Bradfield Canal		Killik River	NR - 5,6-13
			NO - 9-10	Kiska	NM - 60- 2
Washington		Bristol Bay	NO - 4- 8	Kodiak	NO - 5- 8
Bellingham	NM - 10-10	Calignik	NO - 4-11	Kotezebue	NQ - 3,4- 6
Cape Flattery	NM - 10-11	Candle	NQ - 3,4-11	Kuniuak Is.	NP - 3,4-13
Concrete	NM - 10-12	Cape Mendelsohn		Kuskwin Bay	NO - 3- 3
Copalis Beach	NL - 10-1,4		NO - 3- 1	Kwiguk	NP - 3,4- 6
Hoquiam	NL - 10- 5	Chandalar	NQ - 5,6- 3	Lake Clark	NP - 5,6-13
Grangeville	NL - 11- 8	Chandler Lake	NR - 5,6-14	Lime Hills	NP - 5,6- 9
Lewiston	NL - 11- 5	Charley River	NQ - 7,8- 9	Livengood	NQ - 5,6-11
Okanogan	NM - 11-10	Christian	NQ - 5,6- 4	Lookout Ridge	NR - 3,4-12
Pendleton	NL - 11- 7	Circle	NQ - 5,6-12	Marshall	NP - 3,4-10
Ritzville	NL - 11- 1	Coleen	NQ - 7,8- 1	McCarthy	NP - 7,8- 9
Sandpoint	NM - 11-11	Cordova	NP - 5,6-16	McGrath	NP - 5,6- 5
Seattle	NL - 10- 2	Craig	NN - 8- 3	Meade River	NR - 3,4- 8
Spokane	NL - 11- 2	De Long Mtns.	NR - 3,4-14	Medfra	NP - 5,6- 1
The Dalles	NL - 10- 9	Demarcation Pt.	NR - 7,8- 9	Melozitan	NQ - 5,6- 9
Vancouver	NL - 10- 8	Dillingham	NO - 4- 3	Milliston Is.	NO - 6-3
Walla Walla	NL - 11- 4	Dixon Entrance	NN - 8- 7	Misheguk Mtn.	NR - 3,4-15
Wenatchee	NL - 10- 3	Eagle	NQ - 7,8-13	Mt. Fairweather	
Yakima	NL - 10- 6	Fairbanks	NQ - 5,6-15		NO - 8- 4
		False Pass	NN - 3- 6	Mt. Hayes	NP - 5,6- 4
Alaska		Flaxan Island	NR - 5,6- 8	Mt. Katmai	NO - 5- 4
Adak	NM - 1- 2	Fort Randall	NN - 4- 3	Mt. McKinley	NP - 5,6- 2
Afognak	NO - 5- 5	Fort Yukon	NQ - 5,6- 8	Mt. Michelson	NR - 5,6-12
Ambler	NQ - 3,4-4	Gareloi Island	NM - 1- 1	Mt. St. Ellis	NP - 7,8-14
Amukta	NN - 2-11	Goodnews	NO - 4- 1	Naknek	NO - 4- 6
Anchorage	NP - 5,6-11	Gulkana	NP - 5,6- 8	Nebesna	NP - 7,8- 5
Arctic	NR - 5,6-16	Hagemeister	NO - 4- 4	Noatak	NQ - 3,4- 2
Atka	NN - 1-12	Harrison Bay	NR - 5,6- 6	Nome	NQ - 3,4-13
Atlin	NO - 8- 3	Healy	NP - 5,6- 3	Norton Bay	NQ - 3,4-15
Attu	NN - 59-12	Holy Cross	NP - 3,4- 7	Nulato	NQ - 5,4-16
Baird Inlet	NP - 3,4-14	Hooper Bay	NP - 3,4- 9	Nushagok	NO - 4- 5
Baird Mtns.	NQ - 3,4- 3	Howard Pass	NR - 3,4-16	Ophir	NP - 3,4- 4
Barrow	NR - 5,6- 1	Hughes	NQ - 5,6- 5	Petersburg	NO - 8-12
Barten Island	NR - 7,8- 5	Icy Bay	NO - 7- 1	Phillip Smith Mtn.	
Beaver	NQ - 5,6- 7	Iditarod	NP - 3,4- 8		NR - 5,6-15
Beechey Point	NR - 5,6- 7	Ikpikpuk River	NR - 5,6- 9	Point Hope	NR - 3,4-13
Bendelben	NQ - 3,4-10	Iliamna	NO - 5- 1	Point Lay	NR - 3,4-10
Bering Islands	NP - 7,8-13	Juneau	NO - 8- 5	Port Alexander	NO - 8-11
Bethel	NP -	Kagoyak	NO - 5-11	Port Moller	NN - 4- 1
Bettles	NQ - 5,6- 6	Kantishna River	NQ - 5,6-14	Pribilof Is.	NO - 2-12
Beyno Sound	NO - 6- 1	Karluk	NO - 5- 7	Prince Rupert	NN - 9- 4
Big Delta	NQ - 5,6-16	Kateel River	NQ - 3,4-12		
Black	NP - 3,4- 5	Kenal	NP - 5,6-14		

Region 8 (cont'd)
United States Geological Survey and
Army Map Service Quadrangles

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STATES WITHIN REGION

QUADRANGLE NAME	QUADRANGLE NUMBER
Alaska (cont'd)	
Rat Islands	NM - 60- 3
Ruby	NQ - 5,6-13
Russian Mission	NP - 3,4-11
Sagavanirktok	NR - 5,6-11
Samalga Is.	NN - 2-12
Seguam	NN - 2-10
Selawik	NQ - 3,4- 7
Seldovia	NO - 5- 3
Seward	NP - 5,6-15
Shishmaret	NQ - 3,4- 5
Shungnak	NQ - 3,4- 8
Simenof Is.	NN - 4- 5
Sitka	NO - 8- 8
Skagway	NO - 8- 1
Sleet Mute	NP - 3,4-12
Solomon	NQ - 3,4-14
St. Lawrence	NP - 1,2- 4
St. Matthew	NP - 1,2-15
St. Michael	NP - 3,4- 2
Stepovak Bay	NN - 4- 2
Sumdum	NO - 8- 9
Survey Pass	NQ - 5,6- 1
Sutwik Is.	NO - 4-12
Table Mtns.	NR - 7,8-13
Taku River	NO - 8- 6
Talkeetna	NP - 5,6- 6
Talkeetna Mts.	NP - 5,6- 7
Tanacross	NP - 7,8- 1
Tanana	NQ - 5,6-10
Taylor Mtns.	NP - 3,4-16
Teller	NQ - 3,4- 9
Teshekpuk	NR - 5,6- 5
Trinity Is.	NO - 5-10
Tyonek	NP - 5,6-10
Ugashik	NO - 4- 9
Umiat	NR - 5,6-10
Umnak	NN - 2- 9
Unalakleet	NP - 3,4- 3
Unalaska	NN - 3- 7
Unimak	NN - 3- 5
Utokok River	NR - 3,4-11
Valdez	NP - 5,6-12
Wainwright	NR - 3,4- 7
Wiseman	NQ - 5,6- 2
Yakutat	NO - 7- 3

Region 6
United States Geological Survey and Army Map Service Quadrangles

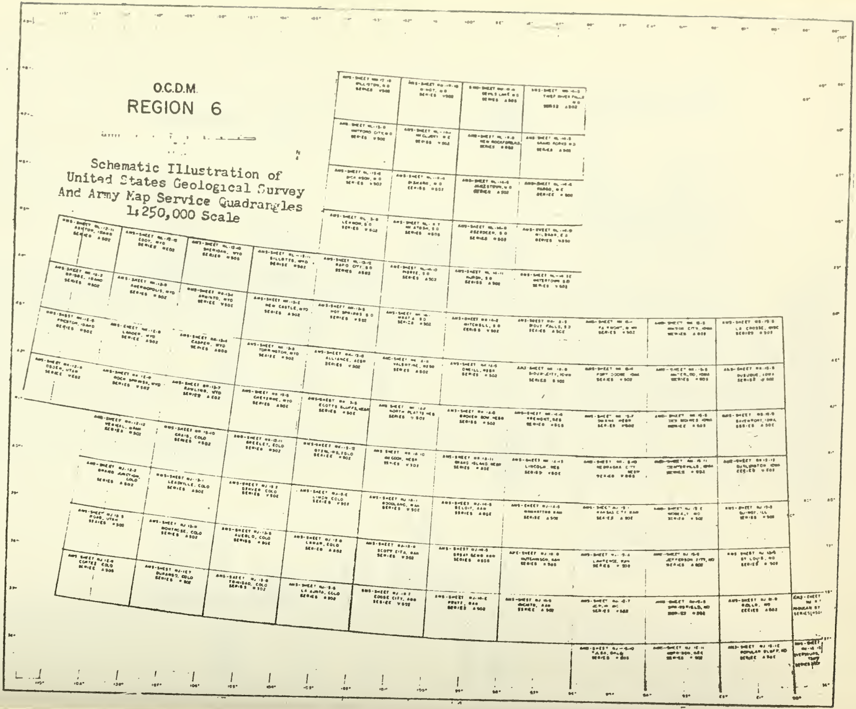
1:500,000 Scale

REGION

Aberdeen - 69
Casper - 60
Chattanooga - 22
Cheyenne - 51
Denver - 41
Des Moines - 49
Dubuque - 58
Fargo - 77
Grand Canyon - 34
Grand Junction - 42
Kansas City - 39
Little Rock - 23
Lincoln - 50
Miles City - 78
Minot - 83
Nashville - 30
Pocatello - 61
Rapid City - 70
Salina - 40
Salt Lake City - 52
Sioux City - 59
Trinidad - 33
Tulsa - 31
Wichita - 32
Williston - 84
Yellowstone Park - 71

STATES WITHIN REGION

STATE	QUADRANGLE NAME	QUADRANGLE NUMBER
Colorado	Cheyenne	51
	Denver	41
	Grand Canyon	34
	Grand Junction	42
	Salt Lake City	52
	Trinidad	33
Iowa	Des Moines	49
	Dubuque	58
	Sioux City	59
Kansas	Kansas City	39
	Salina	40
	Tulsa	31
	Wichita	32
Missouri	Chattanooga	22
	Des Moines	49
	Kansas City	39
	Little Rock	23
	Nashville	30
	Tulsa	31
Nebraska	Casper	60
	Cheyenne	51
	Des Moines	49
	Lincoln	50
	Sioux City	59
North Dakota	Fargo	77
	Miles City	78
	Minot	83
	Williston	84
South Dakota	Aberdeen	69
	Casper	60
	Rapid City	70
	Sioux City	59
Wyoming	Casper	60
	Cheyenne	51
	Pocatello	61
	Rapid City	70
	Salt Lake City	52
	Yellowstone Park	71



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REGION 6

Schematic Illustration of
United States Geological Survey
And Army Map Service Quadrangles
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Region 6
United States Geological Survey and Army Map Service Quadrangles

1:250,000 Scale

REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Aberdeen	NL - 14- 8	Grand Junction	NJ - 12- 3	New Ulm	NL - 15-10
Alliance	NK - 13- 6	Great Bend	NJ - 14- 5	North Platte	NK - 14- 7
Arminto	NK - 13- 1	Greely	NK - 13-11	Ogden	NK - 12- 8
Ashland	NL - 15- 6	Hancock	NL - 16- 1	Omaha	NK - 15- 7
Ashton	NL - 12-11	Hibbing	NL - 15- 2	O'Neill	NK - 14-12
Beloit	NJ - 14- 2	Hot Springs	NK - 13- 3	Pierre	NL - 14-10
Bemidji	NL - 15- 1	Huron	NL - 14-11	Pratt	NJ - 14- 8
Bismark	NL - 14- 4	Hutchinson	NJ - 14- 6	Preston	NK - 12- 5
Brainerd	NL - 15- 4	International Falls	NM - 15-11	Pueblo	NJ - 13- 5
Broken Bow	NK - 14- 8	Jamestown	NL - 14- 5	Quatico	NM - 15-12
Burlington	NK - 15-12	Joplin	NJ - 15- 7	Rapid City	NL - 13-12
Casper	NK - 13- 4	Kansas City	NJ - 15- 1	Rawlings	NK - 13- 7
Centerville	NK - 15-11	Kenora	NM - 15- 7	Hot Springs	NK - 12- 9
Cheyenne	NK - 13- 8	La Crosse	NK - 15- 3	Roseau	NM - 15-10
Cody	NL - 12-12	La Junta	NJ - 13- 9	Santa Cruz	NJ - 10-12
Cortez	NJ - 12- 9	Lamor	NJ - 13- 6	Scott City	NJ - 14- 4
Craig	NK - 13-10	Lander	NK - 12- 6	Scotts Bluff	NK - 13- 9
Davenport	NK - 15- 9	Lawrence	NJ - 15- 4	Sheridan	NL - 13-10
Denver	NJ - 13- 2	Leadville	NJ - 13- 1	Sioux City	NK - 14- 6
Des Moines	NK - 15- 8	Lemmon	NL - 13- 9	Sioux Falls	NK - 14- 3
Devis's Lake	NM - 14-11	Limon	NJ - 13- 3	Sterling	NK - 13-12
Dickinson	NL - 13- 6	Lincoln	NK - 14- 2	Stillwater	NL - 15- 8
Dodge City	NJ - 14- 7	Manhattan	NJ - 14- 3	St. Cloud	NL - 15- 7
Driggs	NK - 12- 2	Martin	NK - 14- 1	St. Paul	NL - 15-11
Dubuque	NK - 15- 6	Mason City	NK - 15- 2	Thermopolis	NK - 12- 3
Duluth	NL - 15- 5	McClusky	NL - 14- 1	Thief River Falls	NM - 14-12
Durango	NJ - 13- 7	McCook	NK - 14-10	Torrington	NK - 13- 5
Eau Clair	NL - 15-12	McIntosh	NL - 14- 7	Trinidad	NJ - 13- 8
Fairmont	NK - 15- 1	Milbank	NL - 14- 9	Two Harbors	NL - 15- 3
Fargo	NL - 14- 6	Minot	NM - 14-10	Valentine	NK - 14- 4
Fort Dodge	NK - 15- 4	Mitchell	NK - 14- 2	Vernal	NK - 12-12
Fort Williams	NM - 16-10	Moab (Delta)	NJ - 12- 6	Waterford City	NL - 13- 3
Fremont	NK - 14- 9	Montrose	NJ - 13- 4	Waterloo	NK - 15- 5
Gillette	NL - 13-11	Nebraska City	NK - 15-10	Watertown	NL - 14-12
Goodland	NJ - 14- 1	New Castle	NK - 13- 2	Wichita	NJ - 14- 9
Grand Forks	NL - 14- 3	New Rockford	NL - 14- 2	Williston	NM - 13-12
Grand Island	NK - 14-11				

Region 6 (cont'd)
United States Geological Survey and
Army Map Service Quadrangles

1:250,000 Scale

STATES WITHIN REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Colorado		Kansas (cont'd)		Nebraska (cont'd)	
Aztec	NJ - 13-10	Goodland	NJ - 14- 1	Scotts Bluff	NK - 13- 9
Cheyenne	NK - 13- 8	Hutchinson	NJ - 14- 6	Sioux City	NK - 14- 6
Cortez	NJ - 12- 9	Joplin	NJ - 15- 7	Torrington	NK - 13- 5
Craig	NK - 13-10	Kansas City	NJ - 15- 1	Valentine	NK - 14- 4
Dalhart	NJ - 13-12	Lawrence	NJ - 15- 4		
Denver	NJ - 13- 2	Manhattan	NJ - 14- 3	North Dakota	
Durango	NJ - 13- 7	McCook	NK - 14-10	Aberdeen	NL - 14- 8
Grand Junction	NJ - 12- 3	Perrytown	NJ - 14-10	Bismarck	NL - 14- 4
Greely	NK - 13-11	Pratt	NJ - 14- 8	Devils Lake	NM - 14-11
La Junta	NJ - 13- 9	Scott City	NJ - 14- 4	Dickinson	NL - 13- 6
Lamar	NJ - 13- 6	Wichita	NJ - 14- 9	Ekalaka	NL - 13- 6
Leadville	NJ - 13- 1			Fargo	NL - 14- 6
Limon	NJ - 13- 3	Missouri		Glendive	NL - 13- 2
Moab (Delta)	NJ - 12- 6	Belleville	NJ - 16- 4	Grand Forks	NL - 14- 3
Montrose	NJ - 13- 4	Blytheville	NI - 16- 1	Jamestown	NL - 14- 5
Pueblo	NJ - 13- 5	Burlington	NK - 15-12	Lemmon	NL - 13- 9
Raton	NJ - 13-11	Centerville	NK - 15-11	McClusky	NL - 14- 1
Rawlings	NK - 13- 7	Dyersburg	NJ - 16-10	Miles City	NL - 13- 5
Rock Springs	NK - 12- 9	Harrison	NJ - 15- 1	Minot	NM - 14-10
Sterling	NK - 13-12	Jefferson	NJ - 15- 5	New Rockford	NL - 14- 2
Trinidad	NJ - 13- 8	Joplin	NJ - 15- 7	Thief River Falls	NM - 14-12
Vernal	NK - 12-12	Kansas City	NJ - 15- 1	Watford City	NL - 13- 3
		Lawrence	NJ - 15- 4	Williston	NM - 13-12
Iowa		Memphis	NI - 15- 3	Wolfpoint	NM - 13-11
Burlington	NK - 15-12	Moberly	NJ - 15- 2		
Centerville	NK - 15-11	Nebraska City	NK - 15-10	South Dakota	
Davenport	NK - 15- 9	Paducah	NJ - 16- 7	Aberdeen	NL - 14- 8
Des Moines	NK - 15- 8	Poplar Bluff	NJ - 15-12	Ekalaka	NL - 13- 8
Dubuque	NK - 15- 6	Quincy	NJ - 15- 3	Gillette	NL - 13-11
Fairmont	NK - 15- 1	Rolla	NJ - 15- 9	Hot Springs	NK - 13- 3
Freemont	NK - 14- 9	Springfield	NJ - 15- 8	Huron	NL - 14-11
Ft. Dodge	NK - 15- 4	St. Louis	NJ - 15- 6	Lemmon	NL - 13- 9
La Crosse	NK - 15- 3	Tulsa	NJ - 15-10	Martin	NK - 14- 1
Mason City	NK - 15- 2			McIntosh	NL - 14- 7
Nebraska City	NK - 15-10	Nebraska		Milbank	NL - 14- 9
Omaha	NK - 15- 7	Alliance	NK - 13- 6	Mitchell	NK - 14- 2
Sioux City	NK - 14- 6	Broken Bow	NK - 14- 8	New Castle	NK - 13- 2
Sioux Falls	NK - 14- 3	Cheyenne	NK - 13- 8	Pierre	NL - 14-10
Waterloo	NK - 15- 5	Fremont	NK - 14- 9	Rapid City	NL - 13-12
		Grand Island	NK - 14-11	Sioux City	NK - 14- 6
Kansas		Lincoln	NK - 14- 2	Sioux Falls	NK - 14- 3
Beloit	NJ - 14- 2	McCook	NK - 14-10	Watertown	NL - 14-12
Dalhart	NJ - 13-12	Nebraska City	NK - 15-10		
Dodge City	NJ - 14- 7	North Platte	NK - 14- 7		
Grand Island	NK - 14-11	Omaha	NK - 15- 7		
Great Bend	NJ - 14- 5	O'Neill	NK - 14-12		

Region 6 (cont'd)
United States Geological Survey and
Army Map Service Quadrangles

1:250,000 Scale

STATES WITHIN REGION

QUADRANGLE NAME	QUADRANGLE NUMBER
Wyoming	
Arminto	NK - 13- 1
Ashton	NL - 12-11
Billings	NL - 12- 9
Casper	NK - 13- 4
Cheyenne	NK - 13- 8
Cody	NL - 12-12
Driggs	NK - 12- 2
Gillette	NL - 13-11
Hardin	NL - 13- 7
Lander	NK - 12- 6
New Castle	NK - 13- 2
Ogden	NK - 12- 8
Preston	NK - 12- 5
Rawlings	NK - 13- 7
Rock Springs	NK - 12- 9
Sheridan	NL - 13-10
Thermopolis	NK - 12- 3
Torrington	NK - 13- 5

Region 7
Schematic Illustration
of
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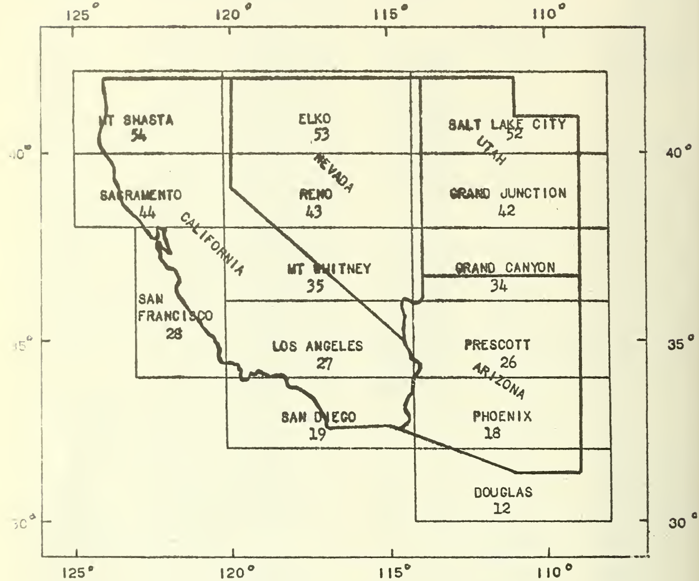


Region 7
United States Geological Survey and Army Map Service Quadrangles

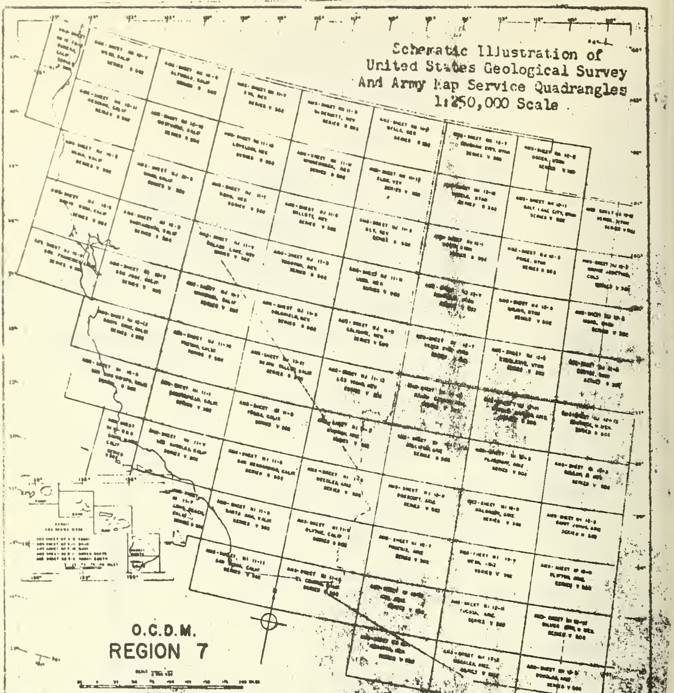
1:500,000 Scale

REGION

Douglas	– 12	Phoenix	– 18
Elko	– 53	Prescott	– 26
Grand Canyon	– 34	Reno	– 43
Grand Junction	– 42	Sacramento	– 44
Los Angeles	– 27	Salt Lake City	– 52
Mt. Shasta	– 54	San Francisco	– 28
Mt. Whitney	– 35	San Diego	– 19

STATES WITHIN REGION

STATE	QUADRANGLE NAME	QUADRANGLE NUMBERS
Arizona	Douglas	12
	Grand Canyon	34
	Los Angeles	27
	Phoenix	18
	Prescott	26
	San Diego	19
California	Elko	53
	Los Angeles	27
	Mt. Shasta	54
	Mt. Whitney	35
	Reno	43
	Sacramento	44
	San Diego	19
	San Francisco	28
Nevada	Elko	53
	Grand Canyon	34
	Grand Junction	42
	Los Angeles	27
	Mt. Whitney	35
	Reno	43
	Salt Lake City	52
Utah	Grand Canyon	34
	Grand Junction	42
	Salt Lake City	52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REGION 7

Region 7
United States Geological Survey and Army Map Service Quadrangles

1:250,000 Scale

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Ajo	NI - 12-10	Kingman	NI - 11- 3	San Bernardino	NI - 11- 5
Alturas	NK - 10- 9	Las Vegas	NJ - 11-12	San Diego	NI - 11-11
Austin	NJ - 11- 2	Long Beach	NI - 11- 7	San Francisco	NJ - 10- 8
Bakersfield	NI - 11- 1	Los Angeles	NI - 11- 4	San Jose	NJ - 10- 9
Brigham City	NK - 12- 7	Lovelock	NK - 11-10	San Luis Obispo	NI - 10- 3
Caliente	NJ - 11- 9	Lund	NJ - 11- 6	Santa Ana	NI - 11- 8
Cedar City	NJ - 12- 7	Marble Canyon	NJ - 12-11	Santa Cruz	NJ - 10-12
Chico	NJ - 10- 3	Mariposa	NJ - 11- 7	Santa Maria	NI - 10-6,9
Clifton	NI - 12- 9	McDermitt	NK - 11- 8	Santa Rosa	NJ - 10- 5
Cortez	NJ - 12- 9	Medford	NK - 10- 5	Shiprock	NJ - 12-12
Death Valley	NJ - 11-11	Mesa	NI - 12- 8	Silver City	NI - 12-12
Delta	NJ - 12- 1	Moab (Delta)	NJ - 12- 6	Sonoyta	NH - 12- 1
Douglas (Bisbee)	NH - 12- 3	Needles	NI - 11- 6	St. Johns	NI - 12- 6
El Centro	NI - 11-12	Nogales	NH - 12- 2	Tonopah	NJ - 11- 5
Elko	NK - 11-12	Ogden	NK - 12- 8	Tooele	NK - 12-10
Ely	NJ - 11- 3	Phoenix	NI - 12- 7	Trona	NI - 11- 2
Escalante	NJ - 12- 8	Prescott	NI - 12- 4	Tucson	NI - 12-11
Eureka	NK - 10-7,10	Price	NJ - 12- 2	Vernal	NK - 12-12
Flagstaff	NI - 12- 2	Redding	NK - 10-11	Vya	NK - 11- 7
Fort Bragg	NJ - 10- 2	Reno	NJ - 11- 1	Walker Lake	NJ - 11- 4
Fresno	NJ - 11-10	Richfield	NJ - 12- 4	Weed	NK - 10- 8
Gallup	NI - 12- 3	Sacramento	NJ - 10- 6	Wells	NK - 11- 9
Goldfield	NJ - 11- 8	Salina	NJ - 12- 5	Westwood	NK - 10-12
Grand Canyon	NJ - 12-10	Salt Lake City	NK - 12-11	Williams	NI - 12- 1
Grand Junction	NJ - 12- 3	Salton Sea	NI - 11- 9	Winnemucca	NK - 11-11
Holbrook	NI - 12- 5				

STATES WITHIN REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Arizona		Arizona (cont'd)		California (cont'd)	
Ajo	NI - 12-10	Salton Sea	NI - 11- 9	Fresno	NJ - 11-10
Clifton	NI - 12- 9	Shiprock	NJ - 12-12	Goldfield	NJ - 11- 8
Douglas	NH - 12- 3	Silver City	NI - 12-12	Kingman	NI - 11- 3
El Centro	NI - 11-12	Sonoyta	NH - 12- 1	Long Beach	NI - 11- 7
Flagstaff	NI - 12- 2	St. Johns	NI - 12- 6	Los Angeles	NI - 11- 4
Gallup	NI - 12- 3	Tucson	NI - 12-11	Mariposa	NJ - 11- 7
Grand Canyon	NJ - 12-10	Williams	NI - 12- 1	Medford	NK - 10- 5
Holbrook	NI - 12- 5			Needles	NI - 11- 6
Kingman	NI - 11- 3	California		Redding	NK - 10-11
Las Vegas	NJ - 11-12	Alturas	NK - 10- 9	Sacramento	NJ - 10- 6
Marble Canyon	NJ - 11-12	Bakersfield	NF - 11- 1	Salton Sea	NI - 11- 9
Mesa	NI - 12- 8	Chico	NJ - 10- 3	San Bernardino	NI - 11- 5
Needles	NI - 11- 6	Death Valley	NJ - 11-11	San Diego	NI - 11-11
Nogales	NH - 12- 2	El Centro	NI - 11-12	San Jose	NJ - 10- 9
Phoenix	NI - 12- 7	Eureka	NK - 10-7,10	San Francisco	NJ - 10- 8
Prescott	NI - 12- 4	Ft. Bragg	NJ - 10- 2	San Luis Obispo	NI - 10- 3

Region 7 (cont'd)
United States Geological Survey and Army Map Service Quadrangles

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QUADRANGLE NAME	QUADRANGLE NUMBER
California (cont'd)	
Santa Ana	NI - 11- 8
Santa Cruz	NJ - 10-12
Santa Maria	NI - 10-6,9
Santa Rosa	NJ - 10- 5
Trona	NI - 11- 2
Walker Lake	NJ - 11- 4
Weed	NK - 10- 8
Westwood	NK - 10-12
Nevada	
Austin	NJ - 11- 2
Caliente	NJ - 11- 9
Death Valley	NJ - 11-11
Elko	NK - 11-12
Ely	NJ - 11- 3
Goldfield	NJ - 11- 8
Kingman	NI - 11- 3
Las Vegas	NJ - 11-12
Lovelock	NK - 11-10
Lund	NJ - 11- 6
Mariposa	NJ - 11- 7
McDermitt	NK - 11- 8
Reno	NJ - 11- 1
Tonapah	NJ - 11- 5
Vya	NK - 11- 7
Walker Lake	NJ - 11- 4
Wells	NK - 11- 9
Winnemucca	NK - 11-11
Utah	
Brigham City	NK - 12- 7
Cedar City	NJ - 12- 7
Cortez	NJ - 12- 9
Delta	NJ - 12- 1
Escalante	NJ - 12- 8
Grand Junction	NJ - 12- 3
Moab (Delta)	NJ - 12- 6
Ogden	NK - 12- 8
Price	NJ - 12- 2
Richfield	NJ - 12- 4
Salina	NJ - 12- 5
Salt Lake City	NK - 12-11
Tooele	NK - 12-10
Vernal	NK - 12-12

Region 8
Schematic Illustration
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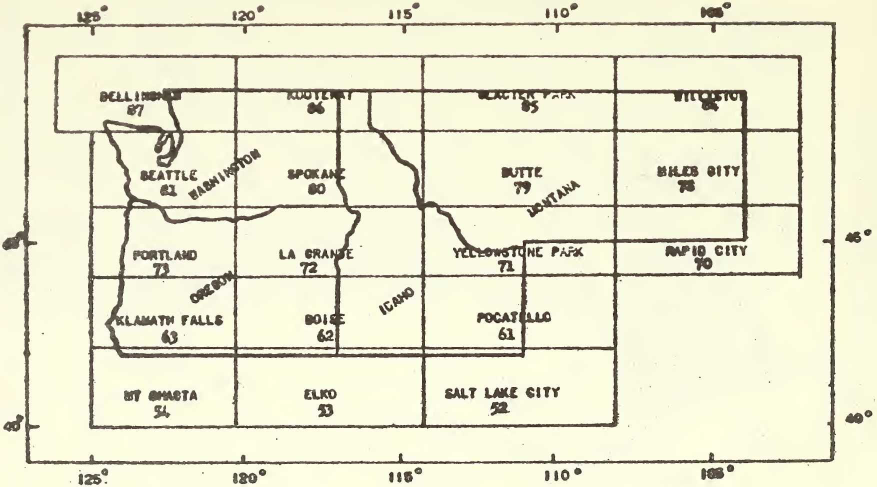

Region 8

United States Geological Survey and Army Map Service Quadrangles

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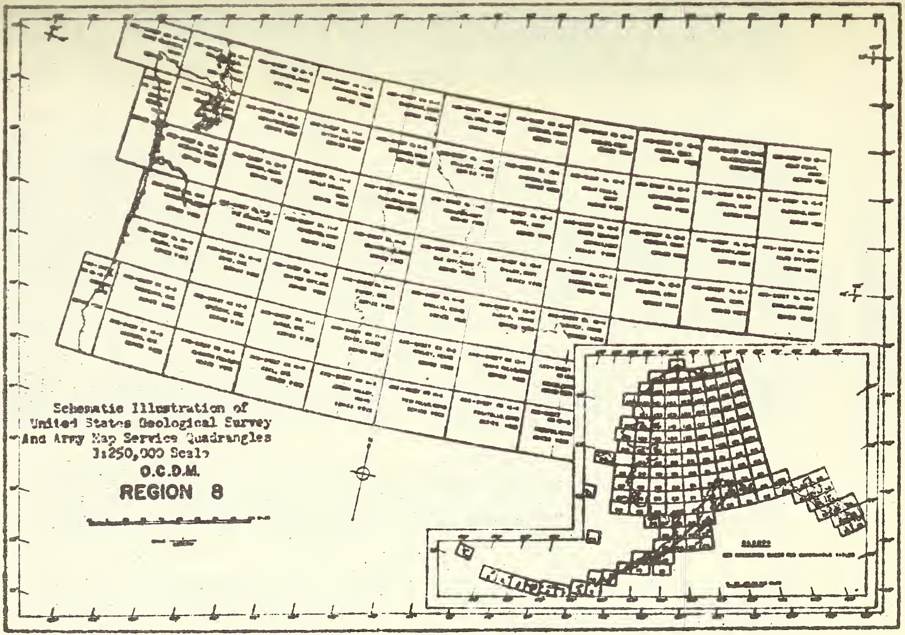
REGION

Bellingham	- 87	Mt. Shasta	- 54
Boise	- 62	Pocatello	- 61
Butte	- 79	Portland	- 73
Elko	- 53	Rapid City	- 70
Glacier Park	- 85	Salt Lake City	- 52
Kootenai	- 86	Seattle	- 81
Klamath Falls	- 63	Spokane	- 80
La Grande	- 72	Williston	- 84
Miles City	- 78	Yellowstone Park	- 71

STATES WITHIN REGION

STATE	QUADRANGLE NAME	QUADRANGLE NUMBER
Idaho	Boise	62
	Elko	53
	Kootenai	86
	La Grande	72
	Pocatello	61
	Salt Lake City	52
	Spokane	80
	Yellowstone Park	71
Montana	Butte	79
	Glacier Park	85
	Kootenai	86
	Miles City	78
	Rapid City	70
	Spokane	80
	Williston	84
	Yellowstone Park	71
Oregon	Boise	62
	Elko	53
	Klamath Falls	63
	La Grande	72
	Mt. Shasta	54
	Portland	73
Washington	Bellingham	87
	Kootenai	86
	La Grande	72
	Portland	73
	Seattle	81
	Spokane	80



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REGION 8

Region 8
United States Geological Survey and Army Map Service Quadrangles

1:250,000 Scale

REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Adel	NK - 11- 4	Dillon	NL - 12- 7	Miles City	NL - 13- 5
Ashton	NL - 12-11	Driggs	NK - 12- 2	Okanogan	NM - 11-10
Bailey	NL - 11-11	Dubois	NL - 12-10	Pendleton	NL - 11- 7
Baker	NM - 10-10	Ekalaka	NL - 13- 8	Pocatello	NK - 12- 4
Bellingham	NL - 10-12	Forsyth	NL - 13- 4	Preston	NK - 12- 5
Bend	NL - 12- 9	Gillette	NL - 13-11	Ritzville	NL - 11- 1
Billings	NK - 11- 2	Glasgow	NM - 13-10	Roseburg	NK - 10- 2
Boise	NL - 12- 8	Glendive	NL - 13- 2	Roundup	NL - 12- 6
Bozeman	NL - 12- 8	Grangeville	NL - 11- 8	Salem	NL - 10-11
Brigham City	NK - 12- 7	Great Falls	NL - 12- 2	Sandpoint	NM - 11-11
Burns	NK - 11- 1	Hamilton	NL - 11- 6	Seattle	NL - 10- 2
Butte	NL - 12- 4	Hardin	NL - 13- 7	Shelby	NM - 12-11
Canyon City	NL - 11-10	Havre	NM - 12- 2	Spokane	NL - 11- 2
Cape Flattery	NM - 10-11	Hoquiam	NL - 10- 5	The Dalles	NL - 10- 9
Challis	NL - 11-12	Idaho Falls	NK - 12- 1	Twin Falls	NK - 11- 6
Chateau	NL - 12- 1	Jordon	NL - 13- 1	Vancouver	NL - 10- 8
Concrete	NM - 10-12	Jordon Valley	NK - 11- 5	Walla Walla	NL - 11- 4
Coos Bay	NK - 10-1,4	Kalispell	NM - 11-12	Wallace	NL - 11- 3
Copalis Beach	NL - 10-1,4	Klamath Falls	NK - 10- 6	Wenatchee	NL - 10- 3
Crescent Lake	NK - 10- 3	Lewiston	NL - 11- 5	White Sulphur Springs	NL - 12- 5
Cut Bank	NM - 12-10	Lewistown	NL - 12- 3	Wolf Point	NM - 13-11
Czizek	NL - 11- 9	Medford	NK - 10- 5	Yakima	NL - 10- 6

STATES WITHIN REGION

QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER	QUADRANGLE NAME	QUADRANGLE NUMBER
Idaho		Montana		Montana (cont'd)	
Ashton	NL - 12-11	Ashton	NL - 12-11	Shelby	NM - 12-11
Bailey	NK - 11- 3	Billings	NL - 12- 9	Wallace	NL - 11- 3
Baker	NL - 11-11	Bozeman	NL - 12- 8	White Sulphur Springs	NL - 11- 3
Boise	NK - 11- 2	Butte	NL - 12- 4	Wolf Point	NM - 13-11
Brigham City	NK - 12- 7	Chateau	NL - 12- 1		
Challis	NL - 11-12	Cutbank	NM - 12-10	Oregon	
Czcizek	NL - 11- 9	Czizek	NL - 11- 9	Adel	NK - 11- 4
Dillon	NI - 12- 7	Dillon	NL - 12- 7	Baker	NL - 11-11
Driggs	NK - 12- 2	Dubois	NL - 12-10	Bend	NL - 10-12
Dubois	NL - 12-10	Ekalaka	NL - 13- 8	Boise	NK - 11- 2
Grangeville	NL - 11- 8	Forsyth	NL - 13- 4	Burns	NK - 11- 1
Hamilton	NL - 11- 6	Gillette	NL - 13-11	Canyon City	NL - 11-10
Idaho Falls	NK - 12- 1	Glasgow	NM - 13-10	Coos Bay	NK - 10-1,4
Jordon Valley	NK - 11- 5	Glendive	NL - 13- 2	Crescent Lake	NK - 10- 3
Lewiston	NL - 11- 5	Great Falls	NL - 13- 2	Grangeville	NL - 11- 8
Pocatello	NK - 12- 4	Hamilton	NL - 12- 6	Hoquiam	NL - 10- 5
Preston	NK - 12- 5	Hardin	NL - 13- 7	Jordon Valley	NK - 11- 5
Sandpoint	NM - 11-11	Harve	NM - 12-12	Klamath Falls	NK - 10- 6
Spokane	NL - 11- 2	Jordan	NL - 13- 1	Lewiston	NL - 11- 5
Twin Falls	NK - 11- 6	Kalispell	NM - 11-12	Medford	NK - 10- 5
Wallace	NL - 11- 3	Lewistown	NL - 12- 3	Pendleton	NL - 11- 7
		Miles City	NL - 13- 5	Roseburg	NK - 10- 2
		Roundup	NL - 12- 6	Salem	NL - 10-11

Region 8 (cont'd)
United States Geological Survey and
Army Map Service Quadrangles

1:250,000 Scale

STATES WITHIN REGION

QUADRANGLE NAME	QUADRANGLE NUMBER
Oregon (cont'd)	
The Dalles	NL - 10- 9
Vancouver	NL - 10- 8
Washington	
Bellingham	NM - 10-10
Cape Flattery	NM - 10-11
Concrete	NM - 10-12
Copalis Beach	NL - 10-1,4
Hoquiam	NL - 10- 5
Grangeville	NL - 11- 8
Lewiston	NL - 11- 5
Okanogan	NM - 11-10
Pendleton	NL - 11- 7
Ritsville	NL - 11- 1
Sandpoint	NM - 11-11
Seattle	NL - 10- 2
Spokane	NL - 11- 2
The Dalles	NL - 10- 9
Vancouver	NL - 10- 8
Walla Walla	NL - 11- 4
Wenatchee	NL - 10- 3
Yakima	NL - 10- 6
Alaska	
Adak	NM - 1- 2
Afognak	NO - 5- 5
Ambler	NQ - 3,4-4
Amukta	NN - 2-11
Anchorage	NP - 5,6-11
Arctic	NR - 5,6-16
Atka	NN - 1-12
Atlin	NO - 6- 3
Attu	NM - 59-12
Baird Inlet	NP - 3,4-14
Baird Mtns.	NQ - 3,4- 3
Barrow	NR - 5,6- 1
Barten Island	NR - 7,8- 5
Beaver	NQ - 5,6- 7
Beechey Point	NR - 5,6- 7
Bendeleben	NQ - 3,4-10
Bering Islands	NP - 7,8-13
Bethel	NP -
Bettles	NQ - 5,6- 6
Beyno Sound	NO - 6- 1
Big Delta	NQ - 5,6-16
Black	NP - 3,4- 5
Alaska (cont'd)	
Black River	NQ - 7,8- 5
Bradfield Canal	NO - 9-10
Bristol Bay	NO - 4- 8
Calignik	NO - 4-11
Candle	NQ - 3,4-11
Cape Mendelsohn	NO - 3- 1
Chandalar	NQ - 5,6- 3
Chandler Lake	NR - 5,6-14
Charley River	NQ - 7,8- 9
Christian	NQ - 5,6- 4
Circle	NQ - 5,6-12
Coleen	NQ - 7,8- 1
Cordova	NP - 5,6-16
Craig	NN - 8- 3
De Long Mtns.	NR - 3,4-14
Demarcation Pt.	NR - 7,8- 9
Dillingham	NO - 4- 3
Dixon Entrance	NN - 8- 7
Eagle	NQ - 7,8-13
Fairbanks	NQ - 5,6-15
False Pass	NN - 3- 6
Flaxman Island	NR - 5,6- 8
Fort Randall	NN - 4- 3
Fort Yukon	NQ - 5,6- 8
Gareloi Island	NM - 1- 1
Goodnews	NO - 4- 1
Gulkana	NP - 5,6- 8
Hagemeister	NO - 4- 4
Harrison Bay	NR - 5,6- 6
Healy	NP - 5,6- 3
Holy Cross	NP - 3,4- 7
Hooper Bay	NP - 3,4- 9
Howard Pass	NR - 3,4-16
Hughes	NQ - 5,6- 5
Icy Bay	NO - 7- 1
Iditarod	NP - 3,4- 8
Ikpikpuk River	NR - 5,6- 9
Iliamna	NO - 5- 1
Juneau	NO - 8- 5
Kagoyak	NO - 5-11
Kantishna River	NQ - 5,6-14
Karluk	NO - 5- 7
Kateel River	NQ - 3,4-12
Kenai	NP - 5,6-14
Alaska (cont'd)	
Ketchikan	NN - 9- 1
Killik River	NR - 5,6-13
Kiska	NM - 60- 2
Kodiak	NO - 5- 6
Kotzebue	NQ - 3,4- 6
Kuniuak Is.	NP - 3,4-13
Kuskokwim Bay	NO - 3- 3
Kwiguk	NP - 3,4- 6
Lake Clark	NP - 5,6-13
Lime Hills	NP - 5,6- 9
Livengood	NQ - 5,6-11
Lookout Ridge	NR - 3,4-12
Marshall	NP - 3,4-10
McCarthy	NP - 7,8- 9
McGrath	NP - 5,6- 5
Meade River	NR - 3,4- 8
Medfra	NP - 5,6- 1
Melozitan	NQ - 5,6- 9
Milliston Is.	NO - 6- 3
Misheguk Mtn.	NR - 3,4-15
Mt. Fairweather	NO - 8- 4
Mt. Hayes	NP - 5,6- 4
Mt. Katmai	NO - 5- 4
Mt. McKinley	NP - 5,6- 2
Mt. Michelson	NR - 5,6-12
Mt. St. Ellis	NP - 7,8-14
Naknek	NO - 4- 6
Nebesna	NP - 7,8- 5
Noatak	NQ - 3,4- 2
Nome	NQ - 3,4-13
Norton Bay	NQ - 3,4-15
Nulato	NQ - 5,4-16
Nushagok	NO - 4- 5
Ophir	NP - 3,4- 4
Petersburg	NO - 8-12
Phillip Smith Mtn.	NR - 5,6-15
Point Hope	NR - 3,4-13
Point Lay	NR - 3,4-10
Port Alexander	NO - 8-11
Port Moller	NN - 4- 1
Pribilof Is.	NO - 2-12
Prince Rupert	NN - 9- 4

Region 8 (cont'd)
United States Geological Survey and
Army Map Service Quadrangles

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STATES WITHIN REGION

QUADRANGLE NAME	QUADRANGLE NUMBER
Alaska (cont'd)	
Rat Islands	NM - 60- 3
Ruby	NQ - 5,6-13
Russian Mission	NP - 3,4-11
Sagavanirktok	NR - 5,6-11
Samalga Is.	NN - 2-12
Seguam	NN - 2-10
Selawik	NQ - 3,4- 7
Seldovia	NO - 5- 3
Seward	NP - 5,6-15
Shishmaret	NQ - 3,4- 5
Shungnak	NQ - 3,4- 8
Simenof Is.	NN - 4- 5
Sitka	NO - 8- 8
Skagway	NO - 8- 1
Sleet Mute	NP - 3,4-12
Solomon	NQ - 3,4-14
St. Lawrence	NP - 1,2- 4
St. Matthew	NP - 1,2-15
St. Michael	NP - 3,4- 2
Stepovak Bay	NN - 4- 2
Sumdum	NO - 8- 9
Survey Pass	NQ - 5,6- 1
Sutwik Is.	NO - 4-12
Table Mtns.	NR - 7,8-13
Taku River	NO - 8- 6
Talkeetna	NP - 5,6- 6
Talkeetna Mts.	NP - 5,6- 7
Tanacross	NP - 7,8- 1
Tanana	NQ - 5,6-10
Taylor Mtns.	NP - 3,4-16
Teller	NQ - 3,4- 9
Teshekpuk	NR - 5,6- 5
Trinity Is.	NO - 5-10
Tyonek	NP - 5,6-10
Ugashik	NO - 4- 9
Umiat	NR - 5,6-10
Umnak	NN - 2- 9
Unalakleet	NP - 3,4- 3
Unalaska	NN - 3- 7
Unimak	NN - 3- 5
Utokok River	NR - 3,4-11
Valdez	NP - 5,6-12
Wainwright	NR - 3,4- 7
Wiseman	NQ - 5,6- 2
Yakutat	NO - 7- 3

Appendix C

Methods and Procedures for Estimating Weapon Yield and Location of Ground Zero

Estimating Weapon Size

"Ball of Fire" or"Flash" C-1

Cloud Paremeters : Height of top, height of bottom and cloud diameter C-4

Height of Cloud (Alternate Procedure) C-5

Cloud Top Angle vs Flash-to-Bang Time C-7

Cloud Bottom Angle vs Flash-to-Bang Time C-8

Cloud Diameter Angle vs Flash-to-Bang Time .... C-9 (10KT - 500KT)

Cloud Diameter Angle vs Flash-to-Bang Time .... C-10 (500KT - 20MT)

Diameter of Cloud (Alternate Procedure) C-11

Estimating Location of A Nuclear Detonation

Estimating Distance from Sound C-17

Estimating Ground Zero by Intersection C-18

Estimating Weapon Size

"Ball of Fire" or "Flash"

Based on figure 2.113, pg.75, of "The Effects of Nuclear Weapons", April 1962, a formula employing the length of time of the flash has been derived for estimating the yield of a detonated weapon. The formula is based on the second portion of the curve wherein the apparent surface temperature relatively slowly rises to a maximum of 8000degrees Centigrade at about 0.15 second followed by the steady decrease over a period of several seconds until the ambient atmospheric temperature is reached. This procedure may be used for nuclear detonations occurring during the day or at night for both air and surface bursts.

METHOD OF ESTIMATING APPROXIMATE SIZE OF WEAPON BY LENGTH OF TIME OF FLASH

Air or Surface Burst

Weapon Size	Length of Time of Flash (seconds)
1 MT	24
3 MT	36
5 MT	47
10 MT	67
20 MT	95

Formula: 0.0022 x Time (seconds) squared equals weapon yield

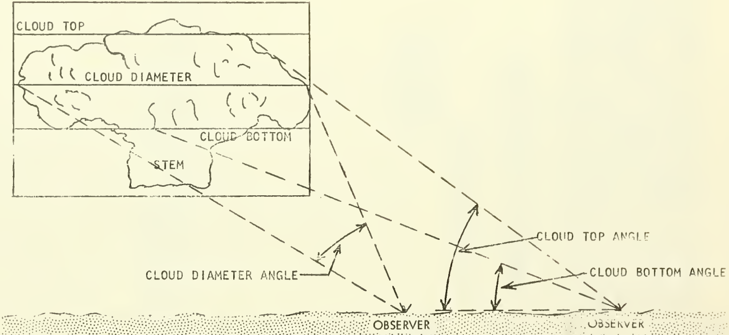
or

$$0.0022 \times \text{Time (seconds)}^2 = \text{weapon yield}$$

Estimating Weapon Size from Cloud Paremeters

- a. Height of top
- b. Height of bottom
- c. Diameter

RADIOACTIVE CLOUD OBSERVATIONS



Cloud top angle is that vertical angle in degrees or mils subtended by a horizontal plane and observer's line of sight to the top of the mushroom cloud. This angle should be measured at about 7 to 10 minutes after the time of the flash.

Cloud bottom angle is that angle in degrees or mils subtended by a horizontal plane and the observer's line of sight to the point of intersection of the mushroom cloud and the stem. This angle should be measured at about 7 to 10 minutes after the time of the flash.

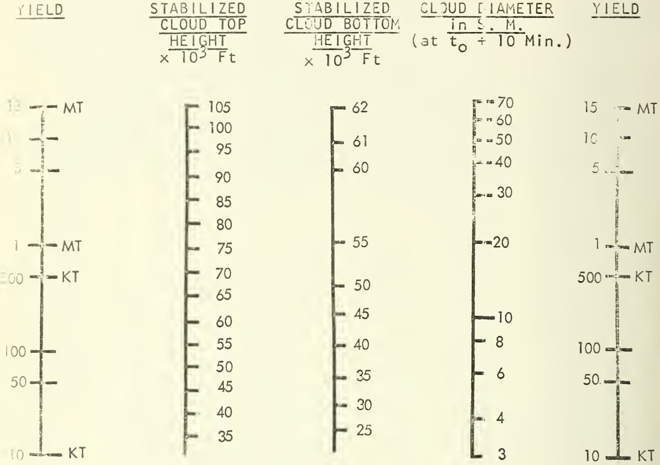
Cloud diameter angle is that angle in degrees or mils subtended by the diameter of the cloud. In situations where it is not possible to distinguish clearly the top or bottom of the cloud, a clear measurement of the cloud diameter angle at 10 minutes after the flash will suffice for determining yield.

Figure C-1

Measurement of Angles

In many cases, instruments such as theodolites, clinometers, telescopes or field glasses will not be available to measure the angles required for estimating the yield of a nuclear explosion. When instruments are not available, angles can be estimated by using hand, fingers or fist held at a fixed distance from the eye. The specific angle subtended by the hand, fingers or fist must be determined by the individual and should be recorded and memorized for rapid use. This can be done by applying the mil relation formula which is based on the assumption that a length of one yard at a distance of 1000 yards will subtend an angle of one mil. For example, an observer notes that two antenna towers 1000 yards apart and about 10,000 yards from his position, require three fingers extended at an arm's length to fill the angle subtended by the two towers. Thus, an observer under these conditions would conclude that three fingers extended an arm's length subtends an angle of 100 mils. Also when instruments are not available, a metal protractor or one constructed from heavy cardboard can be used in conjunction with a string and a weight for determining cloud-top and cloud-bottom angles. A protractor with a pair of movable indices on the circular scale can also be used to sight across to obtain cloud-diameter angles.

RADIOACTIVE CLOUD PARAMETERS



This nomograph for use to determine yield when the cloud parameters, height of top, height of bottom, or diameter have been ascertained. For example, the height of the bottom of a nuclear cloud is reported to be about 55,000 feet. To estimate the corresponding yield, place a straight edge through 55,000 on the middle scale so that the values on the left yield index scale and right yield index scale are the same. The yield as read from the nomograph is about 1 MT.

Figure C-2

Alternate Height of Cloud Technique

In both air and surface bursts, an atomic (radioactive) cloud is formed. For weapons in the megaton range, the atomic cloud rises to considerable heights. Based on this phenomena, a table has been developed showing the "mean top" (plus or minus 20%), in feet, of the cloud for various weapon sizes at 10 minutes after a nuclear detonation. This procedure is limited to surface bursts only. Data for air bursts are not available. The heights of bursts an enemy may employ, for air bursts, are unpredictable. This procedure can be used for bursts ocurring in the daytime. Obviously, the height of the atomic cloud cannot be seen at night.

METHOD OF ESTIMATING APPROXIMATE SIZE OF WEAPON BY HEIGHT OF CLOUD

SURFACE BURSTS ONLY

AVERAGE HEIGHT OF CLOUD PER WEAPON YIELD

Weapon Size	Mean Top of Cloud ++(feet)	Mean Cloud Diameter (miles)	Time After Detonation (Minutes)
1 MT	70,000	20	10
2 MT	76,000	28	10
3 MT	82,000	32	10
4 MT	90,000	34	10
5 MT	93,000	38	10
10 MT	103,000	52	10
15 MT	110,000	66	10
20 MT	113,000	80	10

++NOTE: The mean top of the cloud may vary plus or minus 20% for each size weapon.

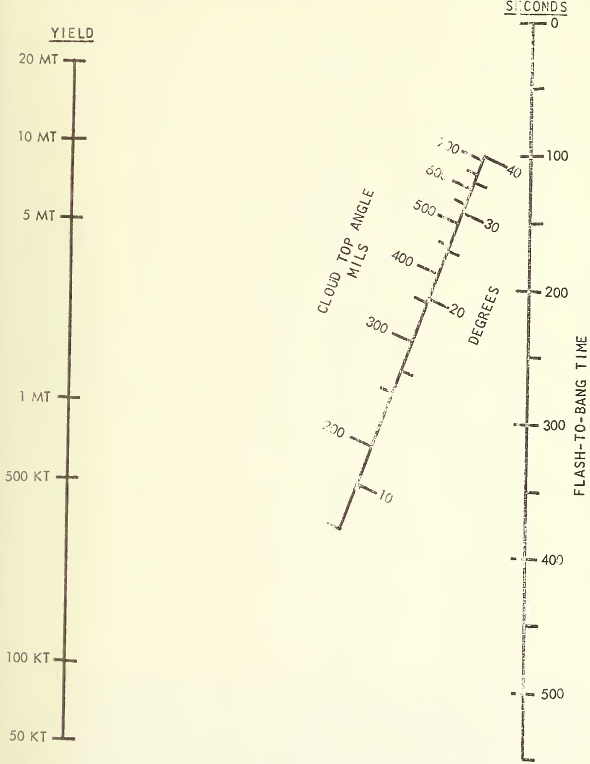
Source: U.S. Weather Bureau, "A Note on Nuclear Cloud Dimensions"-dated Sept. 1959

Estimating Weapon Size from Flash-to-Bang-Time Related to Cloud Tope Angle, Cloud Bottom Angle and Cloud Diameter Angle

Flash - to-Bang Time

Flash-to-bang time is the time interval in seconds between the flash of the explosion and the arrival of the sound of the explosion at the position of an observer, who is at a sufficient distance from ground zero to be unharmed by the primary effects of the nuclear explosion. The sound of the explosion travels at an average velocity of 375 yds/sec for distances from ground zero sufficiently large to be outside the zone of primary effects. Thus, the flash-to-bang time in seconds multiplied by 375 establishes the approximate distance in yards from the observer to ground zero. If a watch or clock is not available, an observer can count "1000", "2000" etc. from the time a flash appears until the sound is heard to determine the approximate flash-to-bang time in seconds.

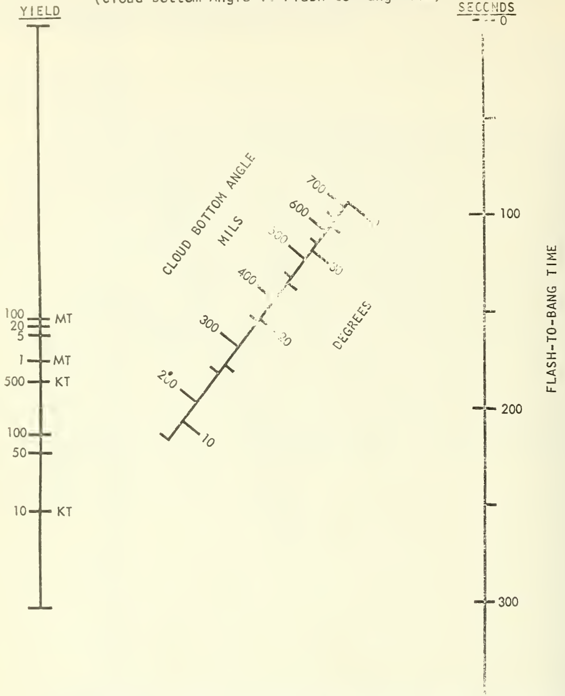
YIELD ESTIMATION
(Cloud Top Angle vs Flash-to-Bang Time)



This nomograph for use to determine yield from cloud top angle and flash-to-bang time. For example, observer notes a flash-bang-time of 250 seconds and measures the angle to the top of the nuclear cloud to be about 15 degrees. To estimate corresponding yield, interesct with a straight edge 250 seconds on the right hand scale and 15 degrees on the center scale. At the point of intersection of the straight edge and the left hand scale read a yield of about 1 MT.

Figure C-3

YIELD ESTIMATION
(Cloud Bottom Angle vs Flash-to-Bang Time)

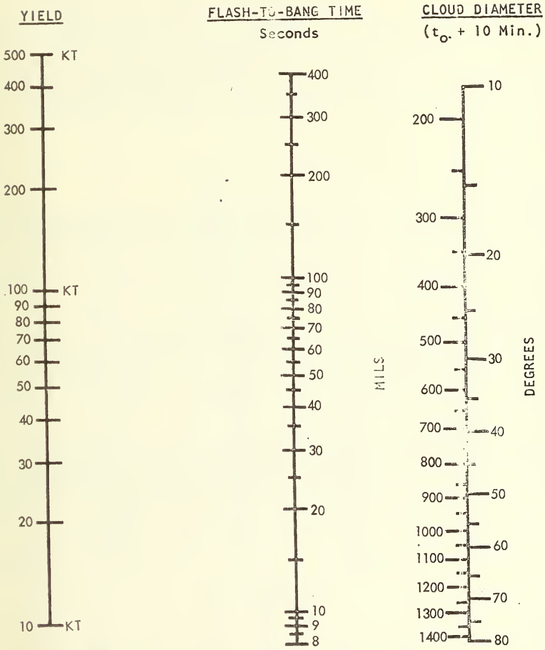


This nomograph for use to determine yield from cloud bottom angle and flash-to-bang time. For example, observer notes a flash-band-time of 250 seconds and measures the angle to the bottom of the nuclear cloud to be about 200 mils. To estimate corresponding yield, intersect with a straight edge 250 seconds on the right hand scale and 200 mils on the center scale. At the point of intersection of the straightedge and the left hand scale read a yield of about 3 MT.

In cases where different yields result from different measurements on the same nuclear cloud, an average yield should derived if measurements are made with about the same degree of accuracy and confidence. However, when any one of the cloud measurements, including cloud diameter angle, is made with a greater degree of accuracy and confidence than the others, the yield which reflects the more accurate and confident measurements should be used.

Figure C-4

YIELD ESTIMATION (10 KT-500 KT)
(Cloud Diameter Angle vs Flash-to-Bang Time)



This nomograph for use to determine yields from cloud diameter angles and flash-to-bang times. For example, an observer notes a flash-to-bang time of 92 seconds and measures the cloud diameter angle to be about 23 degrees. To estimate the corresponding yield, a preliminary of this and the following nomograph must first be made in order to determine which nomograph to use. In this case, using the above nomograph, intersect with a straight edge 23 degrees on the right hand scale and 92 seconds on the center scale. At the point of intersection on the left hand scale read a yield of about 100 KT.

Figure C-5

YIELD ESTIMATION (500 KT-20 MT)
(Cloud Diameter Angle vs Flash-to-Bang Time)

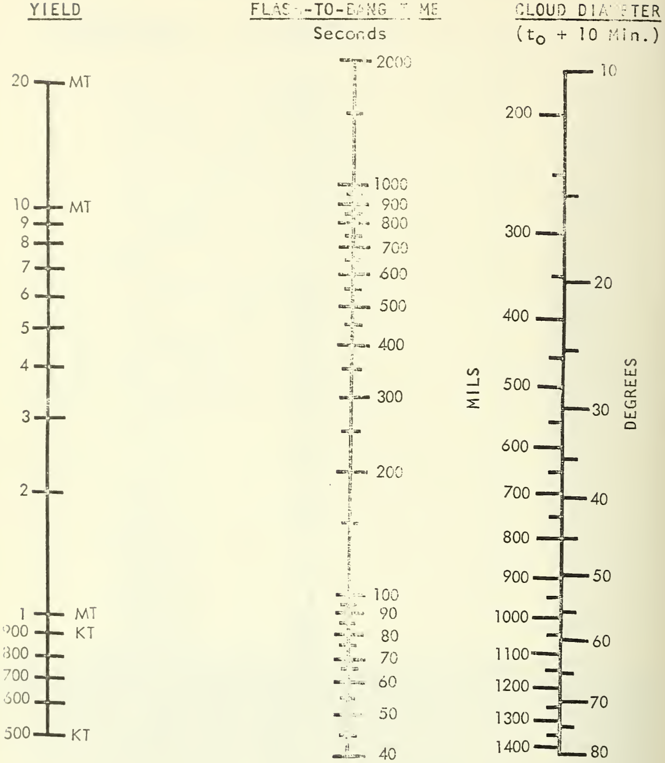


Figure C-6

Diameter of Cloud Technique

An alternate method of estimating the yield of a detonated nuclear weapon is by means of measuring the "maximum diameter" of the atomic cloud. This procedure was developed by the application of trigonometic theory in relation to the following information which appeared in "A Fallout Forecasting Technique with Results Obtained at the Eniwetok Proving Ground, Research and Development Report USNRDL-TR-139, NS081-001-US Army, 3 April 1957, U.S. Naval Radiological Defense Laboratory, San Francisco, California."

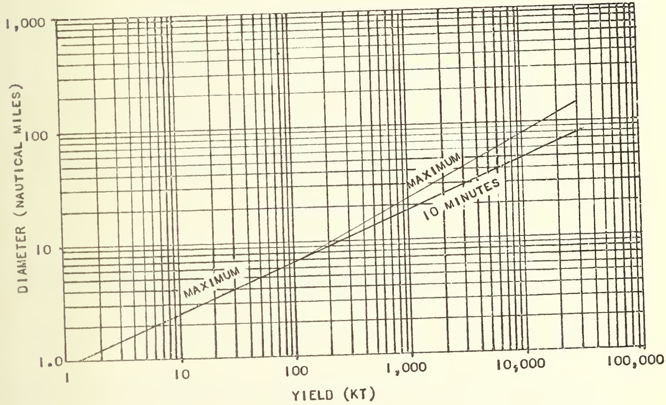


Fig. 1 Mushroom Diameter as a Function of Yield

This procedure may be used for both air and surface bursts. Again, similar to the height of cloud procedure, the maximum diameter of the cloud cannot be seen at night.

Figure C-7

ESTIMATING SIZE OF WEAPON BY DIAMETER OF CLOUD

A method of estimating the approximate size of a detonated nuclear weapon is by determining the diameter of the resultant nuclear cloud. The diameter of the nuclear cloud is obtained, mathematically, as follows:

Diameter (in miles) of nuclear cloud = 2 x tangent of angle θX distance observation point from detonation point.

Angle θ is 1/2 of the measured angle.

Information required to perform the computation is as follows: (see fig C-8)

(1) The estimated distance observation point is from the detonation.

(2) Angular width of cloud (see illustration).

(3) Angle θ (1/2 of the measured angle).

(4) Tangent of angle θ.

Procedure for performing the computation:

(1) Obtain the estimated distance the observation point is from the detonation.

(2) Obtain estimate of the angular width of the cloud by instrument or hand procedure.

(3) Obtain angle θ (1/2 of the measured angle)

(4) Obtain tangent of angle θ.

(5) Multiply tangent of angle θ by 2 and then multiply resultant figure by distance in miles observation point is from detonation.

(6) Figure obtained in miles furnishes the estimated maximum diameter of cloud.

(7) From the table showing for each weapon size the maximum diameter of cloud and measured angles at specific distances from the detonation, estimate the approximate weapon size.

Example of application of procedure:

Problem: Determine weapon size where detonation is 30 miles from the observation point and angular width of cloud has been estimated at 47° 40'.

Solution:
1. Angle θ is 1/2 of 47° 40' or 23° 50'
2. Tangent of 23° 50' is .442.
3. 2 x .442 is .884.
4. .884 x 30 miles is 26.520 miles.
5. Since the maximum diameter of cloud for a 1MT is 26.5 miles, the approximate weapon size was 1MT.

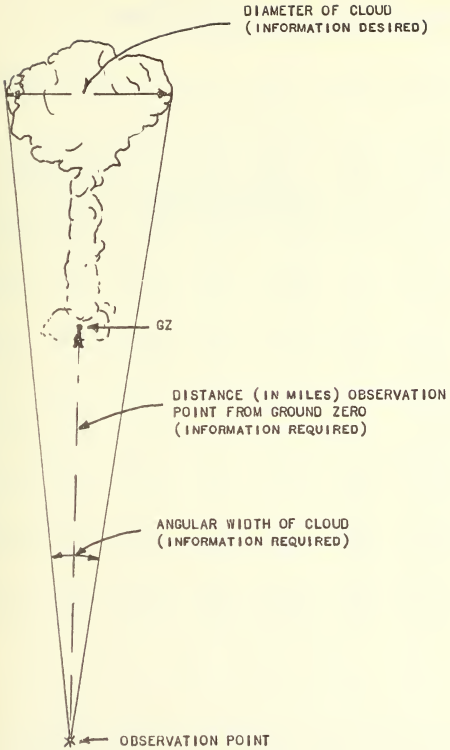

DIAMETER OF CLOUD
(INFORMATION DESIRED)
GZ
DISTANCE (IN MILES) OBSERVATION POINT FROM GROUND ZERO
(INFORMATION REQUIRED)
ANGULAR WIDTH OF CLOUD
(INFORMATION REQUIRED)
OBSERVATION POINT

Figure C-8

MEASURED ANGLES FOR VARIOUS DISTANCES IN MILES
(Observer to Burst)*

Distance Observer to Burst (miles)	1 MT		2 MT		3 MT		4 MT		5 MT		10 MT		15 MT		20 MT	
	Maximum Diameter of Cloud															
	26.5 Miles		36.9 Miles		47.2 Miles		57.6 Miles		62.2 Miles		92.1 Miles		101.0 Miles		138.2 Miles	
	MEASURED ANGLES (Degrees and Minutes)															
	DEG	MIN	DEG	MIN	DEG	MIN	DEG	MIN	DEG	MIN	DEG	MIN	DEG	MIN	DEG	MIN
10	106	00	123	00	134	00	141	42	144	20	155	20	157	48	163	20
20	67	00	85	20	99	30	111	26	114	30	133	00	137	10	147	40
30	47	40	63	10	76	20	87	38	92	00	114	00	119	04	133	00
40	37	00	49	30	61	00	71	30	76	00	98	00	103	48	120	00
50	29	40	40	27	50	30	59	52	64	00	85	20	90	07	108	10
60	24	50	34	30	43	00	51	10	54	50	75	00	80	44	98	00
70	21	20	29	30	37	20	44	40	47	50	66	40	72	09	89	10
80	18	50	26	00	32	50	39	30	42	30	59	50	65	02	81	30
90	16	50	23	10	29	30	35	30	38	10	54	10	59	05	75	00
100	15	10	21	00	26	30	32	00	34	40	49	20	54	03	69	20
110	13	55	19	00	24	15	29	20	31	40	45	30	49	45	64	10
120	12	40	17	30	22	10	27	00	29	10	42	00	46	04	59	50
130	11	40	16	00	20	30	25	00	26	50	39	00	42	54	56	50
140	10	40	15	00	19	10	23	10	25	00	36	30	40	02	52	30
150	10	10	14	00	17	50	21	40	23	30	34	10	37	34	49	20

* All readings must be taken after the flash has disappeared. The cloud does not reach its maximum diameter until 10 to 15 minutes after the burst, therefore, this should not create a problem. Since readings could not be made at night, this method of estimating weapon size applicable for daytime detonations only.

Source: NAV-NRDL-TR-139, pg. 17

Angles, Angles o and Tangents

Distance Observer to Burst (Miles)	Angle o Angle Tangent	1 MT	2 MT	3 MT	4 MT	5 MT	10 MT	15 MT	20 MT
	Angle	106°00'	123°00'	134°00'	141°42'	144°20'	155°20'	157°48'	163°20'
10	o Angle	53°00'	61°30'	67°00'	70°56'	72°10'	77°40'	78°54'	81°40'
	Tangent	1.327	1.842	2.356	2.888	3.108	4.574	5.097	6.827
	Angle	67°00'	85°20'	99°30'	111°26'	114°30'	133°00'	137°10'	147°40'
20	o Angle	33°30'	42°40'	49°45'	55°43'	57°15'	66°30'	68°35'	73°50'
	Tangent	.662	.668	1.179	1.466	1.558	2.300	2.552	3.449
	Angle	47°40'	63°10'	76°20'	87°38'	92°00'	114°00'	119°04'	133°00'
30	o Angle	23°50'	31°35'	38°10'	43°49'	46°00'	57°00'	59°32'	66°30'
	Tangent	.442	.6152	.786	.959	1.036	1.540	1.698	2.300
	Angle	37°00'	49°30'	61°00'	71°30'	76°00'	98°00'	103°48'	120°00'
40	o Angle	18°30'	24°45'	30°30'	35°45'	38°00'	49°00'	51°54'	60°00'
	Tangent	.335	.4599	.589	.7186	.788	1.150	1.275	1.732
	Angle	29°40'	40°27'	50°30'	59°52'	64°00'	85°20'	90°07'	108°00'
50	o Angle	14°50'	20°13'	25°15'	29°56'	32°00'	42°40'	45°03'	54°00'
	Tangent	.265	.3659	.473	.575	.625	.922	1.000	1.376
	Angle	24°50'	34°30'	43°00'	51°10'	54°50'	75°00'	80°44'	98°00'
60	o Angle	12°25'	17°15'	21°30'	25°35'	27°25'	37°30'	40°22'	49°00'
	Tangent	.220	.312	.394	.479	.518	.767	.851	1.150
	Angle	21°20'	29°30'	37°20'	44°40'	47°50'	66°40'	72°09'	89°10'
70	o Angle	11°40'	14°45'	18°40'	22°20'	23°55'	33°20'	36°04'	44°35'
	Tangent	.206	.262	.338	.411	.443	.656	.727	.986
	Angle	18°50'	26°00'	32°50'	39°30'	42°30'	59°50'	65°02'	81°30'
80	o Angle	9°25'	13°00'	16°25'	19°45'	21°15'	29°55'	32°31'	40°45'
	Tangent	.166	.231	.294	.358	.390	.575	.637	.860

Angles, Angles o and Tangents

Distance Observer to Burst (Miles)	Angle o Angle Tangent	1 MT	2 MT	3 MT	4 MT	5 MT	10 MT	15 MT	20 MT
90	Angle	16°50'	23°10'	29°30'	35°30'	38°10'	54°10'	59°05'	75°00'
	o Angle	8°25'	11°35'	14°45'	17°45'	19°05'	27°05'	29°32'	37°30'
	Tangent	.148	.205	.262	.319	.346	.512	.566	.767
100	Angle	15°10'	21°00'	26°30'	32°00'	34°40'	49°20'	54°03'	69°20'
	o Angle	7°35'	10°30'	13°15'	16°00'	17°20'	24°40'	27°01'	34°40'
	Tangent	.133	.185	.236	.287	.312	.459	.510	.692
110	Angle	13°55'	19°00'	24°15'	29°20'	31°40'	45°30'	49°45'	64°10'
	o Angle	6°57'	9°30'	12°07'	14°40'	15°50'	22°45'	24°53'	32°05'
	Tangent	.121	.167	.214	.262	.284	.418	.462	.627
120	Angle	12°40'	17°30'	22°10'	27°00'	29°10'	42°00'	46°04'	59°50'
	o Angle	6°20'	8°45'	11°05'	13°30'	14°35'	21°00'	23°02'	29°55'
	Tangent	.110	.153	.196	.240	.261	.384	.425	.575
130	Angle	11°40'	16°00'	20°30'	25°00'	26°50'	39°00'	42°54'	56°50'
	o Angle	5°50'	8°00'	10°15'	12°30'	13°25'	19°30'	21°27'	28°25'
	Tangent	.102	.140	.182	.222	.238	.354	.392	.541
140	Angle	10°40'	15°00'	19°10'	23°10'	25°00'	36°30'	40°02'	52°30'
	o Angle	5°20'	7°30'	9°35'	11°35'	12°30'	18°15'	20°01'	26°15'
	Tangent	.093	.132	.169	.205	.222	.331	.364	.494
150	Angle	10°10'	14°00'	17°50'	21°40'	23°30'	34°10'	37°34'	49°20'
	o Angle	5°05'	7°00'	8°55'	10°50'	11°45'	17°05'	18°47'	24°40'
	Tangent	.089	.123	.157	.191	.207	.308	.340	.459

Estimating Location of a Nuclear Detonation

The importance of knowing the location and GZ of a detonated nuclear weapon is evident and, therefore, it is essential that provisional procedures be available for determining such information. Two techniques have been developed for obtaining the information. The first technique produces the approximate location of a nuclear detonation; the second technique furnishes the approximate location of ground zero.

Estimating Approximate Location

A method for determining the approximate location of a detonation, after the direction of the "flash" phenomena has been ascertained, i.e., in terms of the eight cardinal direction points, is by means of sound. Since sound travels, in air, at the rate of about 12 miles per minute, an individual can estimate the distance by using the data in Table below. It is assumed, of course, civil defense and other government personnel have been trained to either look at a time piece or start counting immediately after the "flash" has been observed.

Distance Sound Travels at Sea Level

Sound travels approximately:

.2 miles in 1 second
1.0 miles in 5 seconds
12.0 miles in 60 seconds (1 minute)

Time and distance sound will have travelled from time of sighting of flash:

Time (minutes)	Distance (miles)
1	12
2	24
3	36
4	48
5	60
6	72
7	84
8	96
9	108
10	120
11	132
12	144
13	156
14	168
15	180

Remarks: The Speed of Sound in Air is 1087 feet per second.

Source: Websters New Collegiate Dictionary, pg. 807,
"Sonic", Second Edition, 1956

Determining the Approximate Ground Zero Location

A method of locating ground zero is to sight on the center of the cloud stem using a bearing compass to determine the degrees from North in a clockwise fashion. (See fig. C-9)

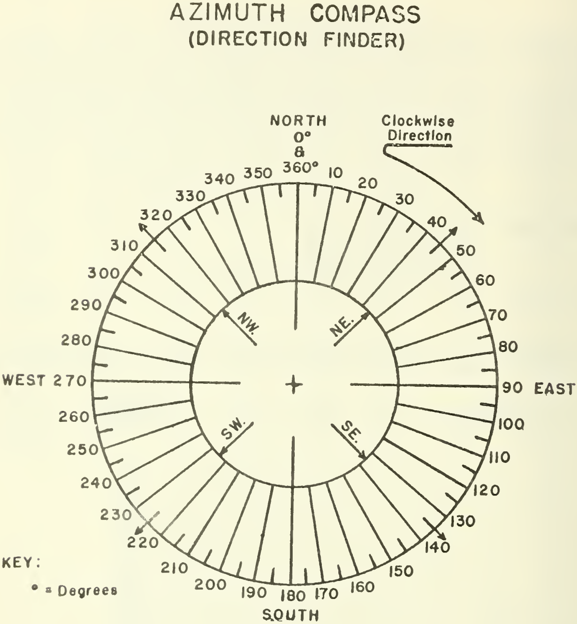


Figure C-9

Three sightings from near opposite directions, when plotted on a map, in the form of lines, will result in an "intersection". Where the lines intersect, a triangle will usually be formed. (See fig. 1.2) The estimated ground zero is obtained by bisecting the lines of the triangle formed as a result of the intersection process.

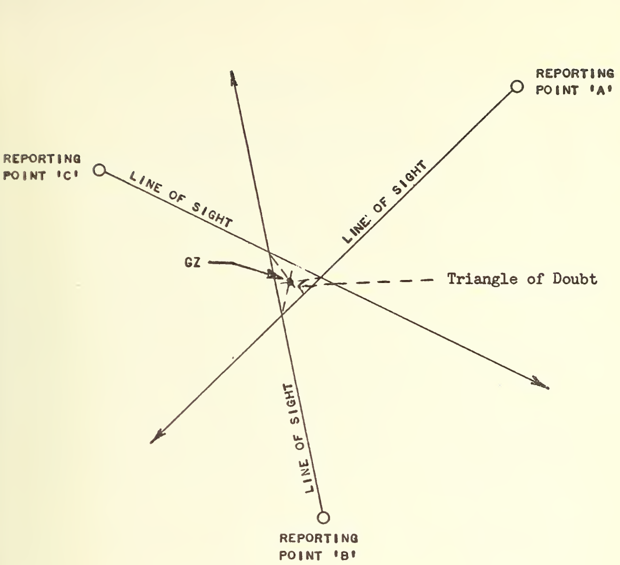


Figure C-10

Procedure:

(1) Obtain "flash" information (direction from where flash was observed) from at least three reporting points. The reporting points should be located within the range of 50 to 100 miles from the detonated area. The reporting point selected for a detonated weapon should be located approximately 90° to 120° apart.

(2) Plot the reporting points on a suitable scaled map, such as 1:2,500,000 scale, showing the locations of the reporting points.

(3) On the map, draw for each reporting point a line toward the direction from where the flash was observed based on an Azimuth Compass.

(4) Where the lines "intersect", a triangle will usually be formed. (See fig.1.2)

(5) Within the triangle, draw three dotted lines as Figure C-10. The mid-point of the three dotted lines is the approximate location of ground zero.

Appendix D

Nuclear Weapons Information

Explosions : Conventional and Nuclear D-1

Atomic and Nuclear Reactions D-2

Fission and Fusion Reactions D-3

Energy Yield of a Nuclear Explosion D-3

Types of Nuclear Explosions ,.............................. D-3

Height of Burst D-4

Ground Zero and Surface Zero D-4

Characteristics of Nuclear Explosions D-5

Casualty and Damage Effects D-15

Square Roots, Cube Roots, Fourth Roots D-22

Appendix D

Nuclear Weapons Information

Explosions-Conventional and Nuclear (Basic Differences)

An explosion is the release of a large amount of energy in a short interval of time within a limited space. Conventional weapons differ from nuclear weapons in the type of reaction involved. In a conventional explosion (TNT), the energy arises from rearrangement among the atoms present in the explosive material. In a nuclear explosion, the energy is produced by the redistribution or recombination of the protons and neutrons within the atomic nuclei. Thus, conventional explosions result from chemical reactions of the atoms; whereas, nuclear explosions result from reactions within the nuclei of the atoms. Nuclear weapons are more powerful than conventional weapons because the forces between the protons and neutrons within atomic nuclei are tremendously greater than those among the atoms as a whole. Nuclear (or atomic) energy, therefore, is of a much higher order of magnitude than conventional energy when equal masses are considered.

A summary of the basic differences between conventional weapons (TNT) and nuclear weapons is as follows:

Conventional Explosion (TNT)	Nuclear Explosion
1. Chemical Reaction - rearrangement among the atoms present in the explosive material.	1. Nuclear Reaction - redistribution or recombination of the protons and neutrons within the nuclei of the atoms.

2. Forces between atoms less than between protons and neutrons within the nuclei of the atoms.	2. Forces between protons and neutrons within the nuclei of atoms greater than forces between atoms.
3. Nearly all energy released appears immediately as kinetic (or heat) energy; almost all converted into blast and shock.	3. Only 85 percent of energy released appears immediately as kinetic (heat) energy. Of the 85%, only 50% converted into blast and shock; 35% converted into thermal radiation, i.e. heat and light rays.
4. No nuclear radiations since atomic nuclei are unaffected.	4. About 15 percent of energy released as various nuclear radiations; 5 percent as initial nuclear radiations (produced within a minute or so of the explosion); 10 percent as residual radiation (produced over a period of time - from the radioactivity of the fission products present in the bomb residue after the explosion).
5. Maximum temperature attained - 5,000°C (9,000°F).	5. Maximum temperature - several million degrees.
6. Material pulverized into smaller pieces.	6. All material converted into gaseous form due to the great heat produced.
7. Pressures produced are several hundred times the atmospheric pressure.	7. Pressures produced are several hundred thousand times the atmospheric pressure - i.e. millions of pounds per square inch.

Atomic and Nuclear Reactions

The terms "Atomic" and "Nuclear" may be used interchangeably, since atomic energy is strictly nuclear energy resulting from particular nuclear reactions. Thus, atomic bombs are called nuclear weapons.

Fission and Fusion Reactions

Many nuclear processes are known. Not all, however, are accompanied by a release of energy. The release of nuclear energy in amounts sufficient to cause an explosion requires that the reaction should be able to reproduce itself once it has been started. Two kinds of nuclear interactions satisfy the conditions for the production of large amounts of energy in a short time. They are known as "fission" and "fusion".

In fission, a free (or unattached) neutron enters the nucleus of a fissionable atom (certain isotopes of uranium or plutoneum) and splits the nucleus into two smaller parts. This is the fission process. It is accompanied by the release of a large amount of energy. The smaller (or lighter) nuclei which result are called the "fission products". The complete fission of 1 pound of uranium or of plutonium can produce as much energy as the explosion of 9,000 tons of TNT.

In fusion, a pair of light nuclei fuse (or unite) together to form a nucleus of a heavier atom with the release of a large amount of energy. The fusion of all nuclei present in 1 pound of the hydrogen isotope deuterium releases roughly the same amount of energy as the explosion of 26,000 tons of TNT. Fusion reactions can be brought about by means of very high temperatures. They are, therefore, referred to as "thermonuclear processes".

A distinction is sometimes made between atomic weapons, in which the energy arises from fission and hydrogen (or thermonuclear) weapons involving fusion. However, both in fission and fusion nuclear reactions are involved. Both, therefore, may be referred to as "nuclear weapons".

Energy Yield of a Nuclear Explosion

The power of a nuclear weapon is expressed in terms of its total energy release (or yield) compared with the energy liberated by TNT when it explodes. Thus, a 1 KT (kiloton) is equivalent to 1,000 tons of TNT; a 1 MT (megaton) is equivalent to 1,000 KT or 1 million tons of TNT.

Types of Nuclear Explosions

For convenience and descriptive purposes only, four types of bursts are distinguished.

(1) Air Bursts
(2) Surface Bursts
(3) Subsurface Bursts
    a. Underwater
    b. Underground

(1) An "air burst" is one in which the bomb is exploded in the air, above land or water, at such a height that the fireball (at maximum brilliance) does not touch the surface.

(2) A "surface burst" is one in which the weapon is exploded either at the actual surface of the land or water or at any height above the surface such that the fireball (at maximum brilliance) touches the land or water.

(3) An "underwater burst" is one in which the bomb is exploded under the surface of water.

(4) An "underground burst" is one in which the bomb is exploded beneath the ground.

Height of Burst (HOB)

Most targets of interest to civil and defense mobilization planners are on the ground. Therefore, the predictions of blast pressures along the ground is more important than the prediction of free air blast pressures. One of the important factors which determines how far a particular pressure from a given weapon will extend along the ground is the height of burst because:

1. The height of burst determines the strength of the original and reflected waves
2. It determines the angle at which the blast wave hits the ground and whether or not a Mach effect occurs.

For civil and defense mobilization planning purposes two types of air bursts are important: (a) a typical and (b) an optimum air burst. A typical air burst is a burst at such a height above the earth that it is expected to cause the maximum blast damage to an average city. For a 1 MT, the height would be at least 2,900 feet above the earth's surface. Such a height would result in negligible local fallout. An optimum air burst is a burst at such a height above the earth that it would cause maximum blast damage to structures on the ground for the particular targets concerned. At Hiroshima and Nagasaki, the height of burst for the 20 KT weapons was about 1,850 feet. Actually, there is no single optimum height of burst, with regard to blast effects, for any specified explosion energy yield, because the chosen height of burst will be determined by the nature of the target. As a rule, strong (or hard) targets will require low air or surface bursts. For weaker targets, which are destroyed or damaged at relatively low overpressures or dynamic pressures, the height of burst may be raised in order to increase the area of damage, since the Mach effect extends the distances at which low pressure result. The air burst data presented in this document are for a typical air burst.

Although four distinct types of bursts have been listed, there is actually no clear line of demarcation between them. As the height of burst is decreased, an air burst gradually assumes the characteristics of a surface burst. Similarly, a surface burst merges into a subsurface burst at a shallow depth, when part of the ball of fire actually breaks through the surface of the land or water.

Ground Zero and Surface Zero

In a discussion of the effects of nuclear detonations, the term "ground zero" and "surface zero" is often used. Ground zero is the point on the earth's surface immediately below (or above) the point of detonation. In some publications, ground zero is called the "hypocenter" of the explosion. For a burst over (or under) water, the corresponding point is generally called "surface zero". Horizontal distances along the ground to which various effects extend are measured from ground zero.

Characteristics of Nuclear Explosions

Characteristics usually associated with nuclear explosions are:

1. The ball of fire (Fireball)
2. The atomic (radioactive) cloud
3. Thermal radiation
4. Air blast
5. Crater
6. Nuclear radiation
    a. Initial radiation
    b. Residual radiation (including fallout)

1. The Fireball

Almost at the instant of a nuclear explosion there is formed an intensely hot and luminous mass, roughly spherical in shape, called the "ball of fire" or "fireball". Although the brightness of the fireball decreases with time, after about seven-tenths (0.7) of a millisecond, the fireball from a 1 MT, air or surface burst, would appear to an observer 60 miles away to be more than 30 times as brilliant as the sun at noon. In several tests, the glare in the sky, in the early hours of dawn, has been visible 400 (or more) miles away. As a general rule, the luminosity of the fireball does not vary greatly with the energy (or power) of the bomb. Page C-1, indicating estimated weapon sizes for different lengths of time (seconds) of flash, is based on the ball of fire phenomena. The application of the intersection procedure for estimating the approximate location of a ground zero (see Appendix C) is also based on the fireball phenomena.

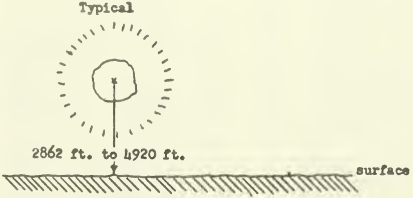
The effects of types of burst on the ball of fire are as follows:

a. Air burst - In a typical air burst, the ball of fire does not touch the surface of the ground.

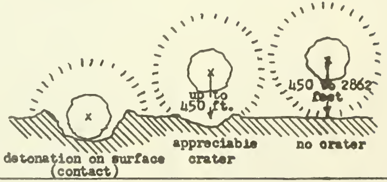
b. Surface burst - In a surface burst, the ball of fire will touch the surface of the earth. Because of the intense heat, a considerable amount of rock, soil and other material located in the area will be vaporized. In a 1 MT, if only 5 percent of the energy is spent in this manner, approximately 20,000 tons of vaporized soil material will be added to the normal constituents of the fireball. In a water surface burst, for a 1 MT, if only 5 percent of the energy is spent in this manner, about 100,000 tons of water will be converted into vapor.

Schematic Illustrations
of
Types of Bursts for a 1 MT

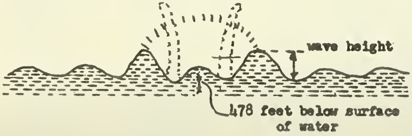
Air Burst



Surface Burst

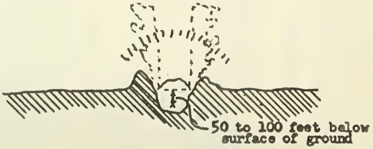


Subsurface Water Burst
(shallow)



Subsurface Underground Burst

Note: Practical considerations suggest that an explosion occurring at a depth greater than 50 to 100 feet is rather improbable. (Source: par 5.4, pg 200, "The Effects of Nuclear Weapons", June 1957.)



c. Subsurface burst - If the detonation is not too deep, the fireball may be partially visible. With deeper bursts no fireball will be visible.

2. The Atomic (radioactive) Cloud

As the fireball increases in size and cools, the vapors condense to form a cloud containing solid particles of the bomb debris, as well as many small drops of water derived from the air sucked into the ascending ball of fire. The color of the atomic cloud thus formed is initially red or reddish brown. As the ball of fire cools further and condensation occurs, the color of the atomic cloud changes to white mainly due to the water droplets. The eventual height of the cloud depends upon the heat energy of the bomb and upon the temperature gradient and density of the surrounding air. The greater the amount of heat liberated, the greater will usually be the upward thrust due to buoyancy and so the greater will be the distance the cloud ascends. It is probable, however, that the maximum height attainable by an atomic cloud is affected by the height of the top of the troposphere, i.e. by the base of the stratosphere, for atomic clouds which reach this level. In the megaton range tests, the tops of the clouds rose to heights of about 25 miles. When the atomic cloud reaches a level where its density is the same as that of the surrounding air, or upon reaching the base of the stratosphere, part of the cloud slows its rise, and starts to spread out horizontally. This forms the mushroom-shaped cloud characteristic of nuclear weapons. The mushroom cloud generally remains visible for about an hour before it is dispersed by the winds into the surrounding atmosphere and merges with other clouds in the sky.

The effects of types of burst on tne atomic cloud are as follows:

a. Air burst - In a typical air burst, the atomic cloud rises to various heights as previously described.
b. Surface burst - In a surface burst, the rate of rise of the atomic cloud is the same as for a typical air burst. The height of cloud, however, does not go as high as from an air burst. In a surface burst the atomic cloud is much more heavily loaded with debris. The exact composition of the cloud depends on the nature of terrain and extent of contact with the ball of fire.

c. Subsurface burst - The atomic cloud from a subsurface burst does not rise as rapidly or go as high as from an air burst.

3. Thermal Radiation

Thermal radiation consists of heat and light produced by a nuclear explosion. The principal characteristics of thermal radiation are that it:

a. Travels at the speed of light (186,000 miles per second)
b. Travels in a straight line
c. Has very little penetrating power
d. Can be easily absorbed or attenuated
e. Can be scattered
f. Can be reflected.

The total amount of thermal energy produced is very great. For every kiloton of yield, approximately 330 billion calories are released. This is equivalent to about 400,000 kilowatt hours. More total thermal energy is released as the yield is increased; however, it is emitted at a slower rate. Because the emission time increases with yield, the amount of thermal energy per unit of area required to produce burns also increases with yield. Since thermal radiation is transmitted at the speed of light, it begins to strike instantaneously following a detonation. Thermal radiation produces burns on people and ignition of combustible materials. Burns are produced in skin (or in any other material) when heat is delivered sufficiently fast to the material that the surface temperature of the material rises sufficiently to cause injury or damage or even ignition of combustible materials. When heat is delivered to a surface so rapidly that it cannot be dissipated by conduction or radiation, this damaging temperature rise occurs. The quantity of heat or thermal energy delivered by thermal radiation is expressed in calories per square centimeter. (A calorie is the amount of heat required to raise the temperature of one gram of water one degree centigrade.) The thermal energy from a nuclear explosion is delivered extremely rapidly during the first portion of the thermal pulse; it is this very rapid delivery of calories which causes the rapid temperature rise in the material it strikes, and which produces a burn on skin, or charring or ignition of other materials.

Because it is easier to measure the total thermal pulse produced by a weapon in calories per square centimeter, than it is to measure the rate of delivery of this energy, the criteria for burns and damage to other materials are usually expressed in calories per square centimeter.

The type of burst is the most important factor to consider when predicting the distance to which thermal radiation extends. All types of bursts - air, surface and underground - release the same amount of thermal energy for a specific weapon yield. However, the amount reaching a specific area from type of burst is different. The effects of types of bursts on thermal radiation are as follows:

a. Air burst - A typical air burst produces the most thermal radiation on a target area.

b. Surface burst - A surface burst produces about 1/3 as much thermal radiation on the target area as an air burst.

c. Subsurface burst - A subsurface burst produces no significant thermal radiation on the target area. Practically all of the thermal radiation is trapped by an underground burst with much of the heat being used to vaporize the surrounding earth.

4. Air Blast

As the gases in the ball of fire move outward rapidly, they push away the surrounding medium - air, water, or earth - with great force, thus causing the destructive (blast or shock) effects of the explosion. This is the "blast" wave. The term "blast" is generally used for the effect in air, because it resembles (and is accompanied by) a very strong wind. The term "shock" is generally used for the effect in water or underground because it is like a sudden impact.

The front of the blast wave is called the "shock front". It moves rapidly away from the fireball, behaving like a moving wall of highly compressed air. In a 1 MT, the blast wave has travelled about 12 miles at 50 seconds after the explosion when the ball of fire is no longer visible. It is then moving at about 1,150 feet per second - slightly faster than the speed of sound at sea level. Initially, the velocity of the shock front is quite high, many times the speed of sound, but as the blast wave progresses outward, it slows down as the shock front weakens. Finally, at long ranges, the blast wave becomes essentially a sound wave and its velocity approaches ambient sound velocity. Table I in Chapter I is based on this phenomenon.

When the blast wave strikes the surface of the earth, it is reflected back. This reflected blast wave is also capable of producing damage. At a certain region on the surface, the direct and reflected shock fronts fuse since the reflected shock front moves faster than the incident shock and eventually overtakes it. This fusion phenomenon is called the "Mach effect". When a bomb is detonated at the surface, i.e. in a contact surface burst, only a single merged wave develops. Consequently, only one shock will be experienced either on or above the ground. The "overpressure" i.e. the pressure in excess of the normal atmospheric value (14.7 pounds per square inch at standard sea level conditions) at the front of the Mach wave is generally about twice as great as that at the direct shock front. The maximum value, i.e. at the shock front, is called the "peak overpressure".

The blast effect of a nuclear weapon is important as both a damaging agent against material and as a casualty producer. Casualties arise from collapsing buildings and flying debris which are caused by blast. Damage to structures arise from the "peak overpressures" and "dynamic overpressures" -- the two forces which produce damage to structures. A difference in the air pressure acting on separate surfaces of a structure produces a force on the structure. Peak overpressures is the force which produces damage by squeezing or crushing material. Dynamic pressures - the measure of the force associated with the high winds immediately following the blast wave as it moves away from the burst point-produce damage by pushing, tumbling or tearing material apart.

The effects of types of burst on air blast are as follows:

a. Air burst - A typical air burst produces the most blast effect.

b. Surface burst - A surface burst produces less blast effect because some of the blast energy is used to produce a crater.

c. Subsurface burst - The underground burst produces the least blast effect because more blast energy is used to produce a larger crater. The deeper the weapon is detonated, the less air blast is produced. Should a weapon be burst deep enough, there would be no blast energy reaching the surface and, therefore, no air blast effects.

In Chapters IV and V will be found tables showing the distances at which specific peak and dynamic overpressures occur for air and surface bursts.

5. Crater

In a surface and subsurface burst, the expanding ball of fire vaporizes, pushes and throws out huge amounts of soil. The result is a crater. If a 1 MT penetrated underground in sandy soil to a depth of about 50 feet before exploding, the resulting crater would be about 190 feet deep and nearly 1,400 feet across. This means that approximately 10 million tons of soil and rock would be hurled upward from the earth's surface.

A considerable amount of earth is carried up into the stem and cloud. Of the earth that is thrown out, a considerable amount falls around the edge of the crater to form a lip. The diameter of this lip is about twice the size of the crater diameter, and its height about 1/4 the crater depth. The shock wave produced by the detonation is transmitted through the surrounding earth, the degree of transmission being dependent on the soil density. Outside the crater for a distance from ground zero to about 1.5 times the crater radius, there are innumerable cracks of various sizes in the soil. This area is called the rupture zone. Outside this rupture zone, there usually is a plastic zone in which there is no visible rupture although the soil is permanently deformed or displaced. In average soil, this plastic zone extends for a distance of about two times the crater radius from ground zero. There is no plastic zone in hard rock.

In general, the size of the crater produced depends on:

a. Weapon yield
b. Type of soil
c. Depth of burst

A typical air burst does not produce a crater. Only surface and subsurface bursts produce a crater. It is believed that, for a 1 MT, there would be no appreciable crater formation unless the detonation occurs at an altitude of 450 feet or less.

Nuclear Radiation

For civil and defense mobilization purposes, two types of nuclear radiations are considered significant. These are (1) initial nuclear radiation and (2) residual nuclear radiation.

a. Initial nuclear radiation - It is that which is emitted by the nuclear explosion within the first minute after the burst. Originating from the fireball, initial nuclear radiation consists of: (1) Alpha and beta particles (2) Gamma radiation and (3) Neutrons. Alpha and beta particles have a very short range. The range of alpha particles is only a few centimeters in the air; beta particles have a range of a few meters in air. Alpha and beta particles have limited penetrating power. The range of gamma rays in air is in thousands of meters; neutrons have a range in air in hundreds of meters. Both have greater penetrating power.

The principal characteristics of initial nuclear radiation are:

1. It travels at the speed of light.
2. It travels essentially along straight lines, although a major portion of the total radiation is scattered at the ranges normally of interest.
3. A portion of the radiation is absorbed by the atmosphere through which it passes.
4. It has very high penetrating power.

The gamma rays travel at the speed of light. Neutrons travel a little more slowly, but still at an extremely fast rate. All the neutrons are emitted within about one second after burst. The initial gamma radiation is emitted over a period of time depending upon weapon yield.

The effects of types of burst on initial nuclear radiation are as follows:

a. Air burst - The amount of initial nuclear radiation produced and received by a target from a typical air burst are about the same as for a surface burst for a weapon size of the same yield. However, if the burst height is low, significant initial nuclear radiation reaches the ground, principally in the form of gamma rays and neutrons. Gamma rays, although harmful to people, do not produce radioactivity in other elements or materials. Neutrons on the other hand, produce radioactivity in certain elements normally found in soil or water. Thus, the neutrons hitting the ground within the vicinity of ground zero penetrate to a depth of about a half a meter and make the soil radioactive. The soil then emits gamma and beta particles. This type of radiation is called "induced" radiation.

b. Surface burst - The amount of initial nuclear radiation produced and received by a target are about the same as for a typical air burst for a weapon size of the same yield.

c. Subsurface burst - The amount received by a target of the same yield as for an air or surface burst is less.

The initial radiation produced by surface and subsurface bursts has little significance when compared to the large amounts of radiation produced by fallout.

b. Residual Nuclear Radiation - Residual radiation is the nuclear radiation emitted after one minute. It is emitted by the radioactive materials originally in a nuclear weapon or created by the burst itself. These radioactive materials can be:

1. Fission products which are newly formed elements and some new isotopes created during the explosion. These fission products emit principally beta particles and gamma radiation.

2. Earth and other radioactive materials which has been made radioactive by the nuclear reaction. These emit principally beta particles and gamma radiation.

Residual radiation does not contain neutrons. However, it consists of alpha and beta particles which may cause significant radiation injury. The effects of types of bursts on residual radiation are as follows:

a. Air burst - In a typical air burst, the radioactive material is carried up with the cloud and the winds spread the cloud over a wide area. These materials later fall to the ground, but are spread over such a wide area that the radioactivity in any one spot is not significant except when precipitation falls through the cloud.

b. Surface burst - In a surface burst, the particles of soil mixed in the fireball scavenge out fission products which then fall back to the ground. As they are falling, the winds scatter them over an extensive area. So much radioactive material falls that the area is contaminated with high intensities of radioactivity (emitted principally in the form of gamma rays and beta particles). This type of residual radiation is called fallout. The extent and nature of fallout can range between wide extremes, and is influenced by a combination of factors. Some of these are:

(1) Yield and design of weapon
(2) The height of burst
(3) Meteorological conditions
(4) Nature of the terrain.

c. Subsurface burst - As regards residual radiation, the same events occur in a subsurface burst as in a surface burst. The major difference between a surface and subsurface burst, is that the area contaminated by low intensities is larger in a surface burst, while the area contaminated by high intensities is smaller from a surface burst.

A summary of the nuclear characteristic for all types of bursts is as follows:

Air, Surface and Subsurface Bursts

Comparison of Characteristic

Characteristic	Air Burst (Typical)	Surface Burst	Subsurface Burst
1. Ball of fire	a. Visible b. Does not Touch surface (ground or water)	a. Visible b. Touches surface (ground or water)	a. If not too deep - visible b. If deep - not visible
2. The atomic (radioactive) cloud	a. Cloud rises to various heights depending on height of burst b. Not too heavily loaded with debris	a. Cloud does not rise as high as in air burst b. More heavily loaded with radioactive debris than an air burst	a. Cloud does not rise as high as in air or surface burst b. More heavily loaded with radioactive debris than an air burst.
3. Thermal radiation	Produces most thermal radiation on target area	Produces about 1/3 as much thermal radiation on target area as an air burst	Produces no significant thermal radiation on target area. Practically all thermal radiation trapped underground
4. Air Blast	Produces most blast effect	Produces less blast effect than in an air burst because some of blast energy used to produce a crater	Produces least blast effect because most of blast energy used to produce a larger crater. The greater the depth of burst, the less the air blast produced. No blast energy would reach surface if detonated deep enough and therefore no air blast effect
5. Crater	No crater produced	Appreciable crater formed (For a 1MT detonation would have to be at 450 feet or less)	Very large crater formed (at 50 feet deep in sandy soil, crater would be 190 feet deep and 1400 feet across)

Characteristic	Air Burst (Typical)	Surface Burst	Subsurface Burst
6. Nuclear Radiation Initial	a. Produces same amount as for a surface burst for a weapon size of same yield b. Amount received by target area same as for a surface burst for a weapon size of same yield	a. Produces same amount amount as an air burst for a weapon size of same yield b. Amount received by target area same as for an air burst for a weapon size of same yield	a. Produces same amount as an air and surface burst for a weapon size of same yield b. Amount received by target area less than for an air or surface burst for a weapon size of same yield
7. Residual	The very small particles rise to such a height that the nuclear radiations no longer reach the ground. Produces no significant radiation in any one spot except when precipitation falls through the cloud.	Produces significant radiation over an extensive area in form of fallout area contaminated by low intensities larger than in a subsurface burst	Area contaminated with high intensities greater than a surface burst

Casualty and Damage Effects

1. Ball of Fire - The flash of light created by the fireball can dazzle people. Dazzle from a burst during daylight hours does not persist for more than about 5 minutes. Only persons facing the burst will be dazzled. At night, dazzle will be sustained by almost all persons within the target area. It persists for about 10 minutes in persons facing the burst and about 3 minutes in all others. Loss of vision, however, persists for much longer periods. Retinal burns will be sustained only when the eye is focused directly on the fireball. Retinal burns leave permanent eye injury and usually result in small permanent blind spots. At night loss of vision may last for periods of several hours.

2. Thermal Radiation - People and things are vulnerable to thermal radiation. People can be burned by the heat. Burns are classified as:

a. First degree - redness of skin (like mild sunburn)
b. Second degree - blistering of skin
c. Third degree - charring of skin and tissue beneath the surface of the skin.

Whether or not people become casualties depends on the severity, location and size of the burn. A burn around the eyes is worse than the same size on the leg. A burn over the whole body is worse than a burn over a small part of the body. A second degree burn is worse than a first degree burn. Second degree burns produce casualties.

The thermal energy from a nuclear explosion will produce primary ignition of dried leaves, grass and rotten wood. Where the radiation gets through the canopy of branches and leaves in a forest, a forest fire may result. Whether or not a forest fire of consequence will develop depends on:

a. Tree canpoy
b. Recent weather (hot and dry or wet)
c. Availability of forest fuels
d. Wind
e. Topography (steep or level terrain)

The growth and spread of the fire will be influenced by the moisture content of the trees, topography and meteorological conditions. Low atmospheric humidity, strong winds, and steep terrain favor the development of forest fires. In general, a deciduous forest (maple, oak, etc.) particularly when in leaf, will burn more slowly than will a coniferous forest (pine, spruce, etc.).

Fires can originate in a city hit by a nuclear weapon in two general ways:

(1) From ignition by direct thermal radiation kindling of fuels such as paper, trash, window curtains, dry grass or leaves; and dry rotted wood, or

(2) From effect of the destruction caused by the blast wave (fires can be started by upset stoves, electric short circuits, and broken gas lines)

The prediction of fires and their results in cities is extremely difficult since the spread of fires in a city depends on a number of factors such as weather, terrain and the spacing and combustibility of buildings. The most important factors are building density and the distance between buildings. The following table shows the probability of fire spread:

Probability of Fire Spread

Probability that the fire will spread (percent)	Distance between buildings (meters)
0	100
10	55
20	30
40	20
60	15
80	8
100	0

3. Air Blast - When considering damage to structures and things, the most important effect in a nuclear explosion is blast. In general, blast damages structures either through the crushing action of the peak overpressure, or through the lateral displacement, tumbling or tearing apart caused by the dynamic pressures. Structures are classified into two types:

(1) Those sensitive to crushing, called "diffraction type"
(2) Those sensitive to lateral displacement, called "drag type".

Damage to structures is classified by degree as:

a. Severe damage

b. Moderate damage

c. Slight damage

Severe damage - A degree of damage that precludes further use of the structure or object for its intended purpose without essentially complete reconstruction. For a structure or building, collapse is generally implied.

Moderate damage - A degree of damage to principal members that precludes effective use of the structure or object for its intended purpose unless major repairs are made.

Slight Damage - A degree of damage to buildings resulting in broken windows, slight damage to roofing and siding, blowing down of light interior partitions, and slight cracking of curtain walls in buildings.

Damage radii for various diffraction and drag type structures as well as other types of features are contained in the appropriate chapters. The radii data are based on a combination of theoretical analysis with data obtained from actual nuclear explosions both in Japan and at various tests, as well as from laboratory studies. However, the nature of any target complex, especially a city is such that no exact prediction of the effect of blast on structures can be made. Nor is it possible to indicate the reliability of the prediction for any particular situation. Nevertheless, by the application of proper judgement to the available information, it is believed that results of practical value can be obtained. The data presented in this document are based on information believed to be the most representative for the average situation that might be encountered in actual target complexes.

In addition to the damage criteria furnished for various specific structural types, damage criteria are furnished ~~in Chapter~~ 5 , for describing or classifying the damage to a city complex. This system classifies damage to average buildings in a city and is useful for gross planning purposes. Since it refers to average conditions, it should not be used to describe damage suffered by a structure which may be stronger or weaker than the average or for such features as aircraft and ships.

Effects on people, unlike damage, are not classified as to degree. Casualties are classified as: (a) Deaths (b) Surviving injured (c) Uninjured. The term "casualties", thus, includes deaths (fatalities). Chapter 6 contains casualty multipliers to use with the casualty zones.

The direct effects of blast to people are from peak overpressures and translational forces.

(1) People are relatively immune to peak overpressures. Very high overpressures (100 psi or more) are required to cause deaths. However, severe internal injuries may be sustained from overpressures as low as 7 psi.

(2) The translational effects which cause people to be picked up and thrown by the blast and to receive injuries upon landing, is an important casualty producer.

The indirect effects of blast are important casualty producers. The more important of these indirect effects are:

(1) Flying debris hitting people. (missile effect) Tests indicate that overpressures as low as 5 psi can produce 200 to 600 missiles per square meter flying at a speed of 20 to 100 meters per second.

(2) Buildings collapsing on people. Blast-blown debris and collapsing buildings in cities can cause casualties to a proportion of the total population unless both timely warning and shelters are available.

Persons in the open, standing, will be picked up and thrown by overpressures of about 8 psi; those in a flat position, will be picked up and thrown by overpressures of about 12 psi. Whether or not these become casualties depends on how and what they strike and their velocity at the time of impact.

4. Crater - Within the crater itself there is complete destruction. From the edge of the crater out to the end of the plastic zone varying degrees of damage may be expected for different types of underground features.

5. Nuclear Radiation

a. Initial Nuclear Radiation - At the same time that the thermal flash is occurring, large quantities of nuclear radiation (primarily neutron and gamma) are also emitted from the fireball. The amount of initial nuclear radiation received by a person or object depends in part on the density of the air between the nuclear burst and person or object. At the same distance the denser air at sea level absorbs more radiation than does the thinner air at high altitudes. Because of the very high penetrating power of both neutrons and gamma rays, large amounts of material around an individual are required to get a reasonable degree of protection. For a given thickness, materials that contain the heavy elements (dense materials such as lead) offers the best protection against gamma rays. Pound for pound materials that contain light chemical atoms (such as water or concrete) offer the best protection against neutrons. The initial nuclear radiations are effective for approximately the first minute after the explosion. Generally for larger yield weapons, the effective range of these radiations is within the region where severe thermal and blast effects are present. Therefore, initial nuclear radiation from large yield weapons is of little concern except perhaps in blast shelters. Any radiation injury from initial nuclear radiation is caused almost completely by neutrons and gamma rays. The range in air of alpha and beta particles is so short that they do not contribute to the initial radiation hazard. Although there is some scatter, the bulk of the gamma radiation dose is received by an individual from one side - the side facing the burst. However, because of extensive scattering in air, the directions of motion of neutrons are almost randomly distributed, requiring shielding on all sides.

b. Residual Radiation - Residual radiation, unlike initial radiation which comes from the fireball, is emitted by the radioactive material originally in the nuclear weapon or created by the burst itself. The radioactive materials can be fission products which are newly formed elements, that is radioactive isotopes created by the splitting of heavier atoms during the explosion. Because of the tremendous heat induced convective action caused by a nuclear explosion, the pulverized and gaseous materials from the crater (from a surface burst) are drawn into the ascending nuclear cloud. The earth particles are mixed with the radioactive materials formed by the fission process in the weapon's detonation. Upon recondensation many of the earth's particles merge with the radioactive fission fragments becoming contaminated. These fission products emit principally beta particles and gamma rays.

Neutron capture may make other materials such as earth, bomb casing and part of the atmosphere in the immediate vicinity of the point of detonation radioactive. Much of the induced radioactive material will also be drawn into the ascending nuclear cloud adding to the radioactivity resulting from the fission process. The induced radioactive materials emit principally gamma radiation and beta particles.

Beta particles from early fallout may cause serious burns on the skin, however, this can be prevented by wearing ordinary heavy clothing to keep fallout particles from coming in contact with the body. During the early postattack period the most dangerous radiation from fallout is gamma radiation which can penetrate to all parts of the body.

An unprotected individual in a radioactive fallout area would receive gamma rays from all directions.

c. The following is a comparison between initial and residual radiations as hazards to objects and people:

Nuclear Radiation

Initial	Residual
1. Is emitted within one minute after the burst	1. Is emitted later than one minute after the burst
2. Objects receive total dose almost all at once	2. Objects receive radiation continuously, accumulating a total dose over a period of time
3. Contains neutrons	3. Does not contain neutrons
4. Contribution of beta particles to radiation injury is negligible	4. Contribution of beta particles to radiation injury may be significant
5. Originates principally from the fireball	5. Comes from radioactive material which may be in form of fallout particles
6. The amount of protection provided by the same protective conditions is usually lesser than for residual radiation.	6. The amount of protection provided by the same protective conditions is usually greater than for initial radiation.

d. Nuclear Radiation Injuries - The injurious effects of nuclear radiation resulting from a nuclear explosion represents a phenomenon which is completely absent from conventional explosions. The harmful effects of nuclear radiation appear to be caused by the ionization (and excitation) produced in the cells composing living tissue. As a result of ionization, some of the constituents, which are essential to the normal functioning of the cells are altered or broken into smaller segments. In addition, the products formed may act as poisons. Among the observed consequences of the action of ionizing radiation on cells are breaking of the chromosomes, swelling of the nucleus and of the entire cell, increase in viscosity of the cell fluid, increased permeability of the cell membrane, and destruction of cells. In addition, the process of cell division is delayed by exposure to radiation. Frequently, the cells are unable to undergo the division process, so that the normal cell replacement occurring in the living organism is inhibited.

e. General Terminology

(1) Unit of Measurement - There are several units of nuclear radiation measurement. However, for simplicity, the roentgen is generally accepted by civil defense to express the measurement of exposure to nuclear radiation. The following statements concerning radiation units are not precise from the scientific point of view, but are simplified so that familiarity may be attained with the associated term and its application.

(a) The roentgen is a unit of radiation quantity, defined as that amount of X or gamma radiation which produces one electrostatic unit of charge of either sign in one cubic centimeter of air at standard temperature and pressure. It is used to measure X and gamma radiation only and has no meaning in the measurement of alpha, beta, or neutron radiation.

(b) The rem is derived from the words "roentgen equivalent man or mammal" and is used to express the quantity of any type of radiation which produces the same biological effects in man as those resulting from exposure to one roentgen of X or gamma radiation.

(2) Radiation Dose - The amount of ionizing nuclear radiation to which an individual is exposed is referred to as the radiation dose and is generally expressed in roentgens (r). For civil defense purposes under emergency conditions, an exposure that ranges in duration from a few seconds to four days is termed brief. When the period of continuous or intermittent exposure is longer than four days, it is termed protracted. These terms, applied to dose or exposure dose, are more appropriate than acute and chronic, respectively, which are used conventionally to describe the severity and duration of an illness or injury.

(3) Radiation Dose Rate - The radiation dose rate is the rate at which radiation is being received at a given point. The gamma component of radiation is measured in units of roentgens per hour (r/hr). Dose rate is commonly referred to as intensity.

(4) Radioactive Decay - Decay is the process wherein fission products eventually become stable nonradioactive isotopes. During the "decay" process gamma and/or beta radiations are emitted. As the radioactivity of fallout decreases due to decay, the dose rates in the environ decrease correspondingly. Because of the continuous change of dose rate with time, it is useful to select a reference time on which to base calculations of expected total dose. The reference time most frequently used is one hour after burst expressed as H + 1.

f. Equivalent Residual Dose (ERD) - Since a major portion of the injury resulting from exposure to radiation may be repaired, the total dose (r) is not by itself a reliable basis for predicting the clinical outcome. The concept of the equivalent residual dose (ERD) has been developed to permit a more reliable prediction of the biological and medical consequences of exposure to radiation than is possible on the basis of accumulated dose alone. The ERD, expressed in roentgens, is the accumulated dose corrected from the recovery assumed to have occurred at a specific time. The ERD concept assumes that, given an opportunity, the body can repair 90 percent of the total injury. It is further assumed that, starting with the fifth day after exposure, radiation injury is repaired at the rate of 2-1/2 percent per day of the remaining repairable injury. At this rate of recovery, half of the repairable injury would be repaired in about a month. It is presumed that a person's ERD would manifest itself in approximately the same symptoms of radiation injury as would be anticipated following a brief dose of the same size.

g. The following condensed table may be used for estimating the consequences to be expected from a short term external, gamma radiation dose or an ERD which has not greatly exceeded 200 r.

Consequences or Effects	Short Term Dose ERD
(1) Smallest effect detectable by statistical study of blood counts of a large group of people......................................	15 r
(2) Smallest effect detectable in an individual by laboratory methods........................	50 r
(3) Smallest dose that causes vomiting on day of exposure in at least 10 percent of people ...	75 r
(4) Smallest dose that causes epilation (loss of hair) in at least 10 percent.................	100 r

Consequences or Effects	Short Term Dose ERD
(5) Largest dose that does not cause illness severe enough to require medical care in majority of people (more than 9 out of 10)	200 r
(6) Dose that would be fatal to about 50 percent of the people	450 r
(7) Dose that would be fatal to almost everyone	600 r

Square Roots, Cube Roots, and Fourth Roots

Number MT	(a) Square Root ($W^{1/2}$)	(b) Cube Root ($W^{1/3}$)	(c) Fourth Power ($W^{1/4}$)	(d) $W^{2/5}$*
1	1.000	1.000	1.000	1.000
2	1.41	1.26	1.19	1.32
3	1.73	1.44	1.32	1.55
4	2.00	1.59	1.41	1.74
5	2.24	1.71	1.49	1.90
6	2.45	1.82	1.57	2.05
7	2.65	1.91	1.63	2.18
8	2.83	2.00	1.68	2.30
9	3.00	2.08	1.73	2.41
10	3.16	2.15	1.78	2.51
11	3.17	2.22	1.82	2.61
12	3.46	2.29	1.86	2.70
13	3.61	2.35	1.90	2.79
14	3.74	2.41	1.93	2.88
15	3.87	2.47	1.97	2.96
16	4.00	2.52	2.00	3.03
17	4.12	2.57	2.03	3.11
18	4.24	2.62	2.06	3.18
19	4.36	2.67	2.09	3.25
20	4.47	2.71	2.12	3.32

* $W^{2/5} = W^{0.4}$

Appendix E

Deposition of Fallout

a. Fallout Forecasts - Since civil defense is assigned the responsibility for the over-all radiological defense system, it is necessary that communities over 500 population, State and county governments and certain special installations have a radiological defense officer and one or more assistants in the emergency operating center (EOC) to plan, organize, implement and operate the radiological defense system. Among the assigned functions, the RADEF officer has the responsibility for the preparation, education and interpretation of fallout forecasts. The present fallout forecast system is appropriate for civil defense use and in competent hands serves a valuable purpose in the program. However, the use of forecasts without the assistance of RADEF personnel, who have access to the available current postattack radiological information, may not be in accord with the measures adopted to insure survival with the fewest possible casualties.

b. Planning for Forecasts Preparation - In his planning, the RADEF officer must make arrangements for the routine receipt of the current upper fallout (UF) wind data that might affect his area. Data should generally be obtained from weather stations within a 300 mile radius. At State and larger local EOC's, the RADEF officer should also make prior arrangements to have a Weather Bureau of private meteorologist on the control center staff to assist in the preparation of fallout forecasts and in preparing the fallout analyses.

c. Use of Fallout Forecasts - The RADEF officer should develop capability within the EOC to apply current wind vector data (UF) to NUDET locations, so that fallout forecasts may be prepared and issued as appropriate. Protractors, compass cards or templates are needed to determine directions in degrees from true north since the wind data are transmitted in these coordinates. Maps depicting all areas within a 500 mile radius should be used. Maps scaled to 1:2,500,000 are appropriate for use at OCD Region and State; however, to enable more detailed plotting of data, maps of larger scale are necessary at local EOC's.

The RADEF officer is cautioned not to place greater use or reliance on the forecasts than is warranted. When current wind data are used, the forecasts can provide a fairly valid indication of the direction and average speed of spread of fallout along the surface of the earth. Federal Guidance for State and Local Civil Defense, Part V, Chapter 5, Appendix 6, "Application of Meteorological Data," provides guidance to assist the Radiological Officer in the use of meteorological te:

(1) prepare area fallout forecasts and estimates of fallout arrival time for operational use,

(2) use in conjunction with dose rate contour and total dose tables shown in chapter __________ to assist in making rough estimates for very early damage assessment prior to receipt of radiological monitoring reports during actual operations and/or for use in training and exercise,

(3) prepare hypothetical dose rate contours for use in conjunction with tests and exercises, and

(4) determine the probability of fallout occurrence in specific areas as a basis for preattack planning.

Appendix F

Federal Civil Defense Guide

Office of Civil Defense

> " develop plans and operate systems to undertake a nationwide postattack assessment of the nature and extent of the damage resulting from enemy attack and the surviving resources, including systems to monitor and report specific hazards resulting from the detonation or use of special weapons..."

Executive Order 10952, As Amended - July 20,1961
(Section 1 (b) (i)

Secretary of Interior

> " Maintain a capability to assess the effects of attack on assigned products, producing facilities, and departmental installations both at national and field levels, and provide data to the Department of Defense."

Executive Order 10997, February 16, 1962
(Section 4 (c))

Secretary of Agrictulture

> " Maintain a capability to assess the effects of attack on assigned resource areas and departmental installations, both at national and field levels, and provide data to the Department of Defense."

Executive Order 10998 , February 16, 1962
(Section 4 (e))

Secretary of Commerce

> " Maintain a capability to assess the effects of attack on assigned resource areas and departmental installations, both at national and field levels, and provide data to the Department of Defense".

Executive Order 10999, February 16, 1962
(Section 6 (e))

Secretary of Labor

" Maintain a capability to assess the effects of attack upon manpower resources, departmental installations, and State Employment Security agencies, both at national and field levels, and provide data to the Department of Defense."

Executive Order 11000, February 16, 1962
(Section 2, (i))

Secretary of Health, Education, and Welfare

" Maintain a capability to assess the effects of attack on health, welfare, and education facilities and personnel both at national and field levels and provide data to the Department of Defense."

Executive Order 11001, February 16, 1962
(Section 6 (b))

Postmaster General

" Maintain a capability to assess the effects of attack on its postal service and resources, both at national and field levels, and provide data to the Department of Defense."

Executive Order 11002, February 16, 1962
(Section 2 (b))

Administrator of the Federal Aviation Agency

" Maintain a capability to assess the effects of attack on all air navigation, air traffic control, and aeronautical communications facilities, all civil airports, civil aircraft, and all other facilities essential to safe and effective air transportation operations in a national emergency and provide data to the Department of Defense."

Executive Order 11003, February 16, 1962
(Section 3 (e))

Housing and Home Finance Administrator

" Maintain a capability to assess the effects of attack on housing resources, both at national and field levels, and and provide data assistance to the Department of Defense."

Executive Order 11004, February 16, 1962
(Section 3 (f))

Interstate Commerce Commission

" Maintain a capability to assess the effects of attack on all domestic surface transportation and storage facilities essential to safe and effective surface transportation in a national emergency, and to provide data to the Department of Defense. "

Executive Order 11005, February 16, 1962
(Section 4 (c))

Secretary of State

None

Secretary of Treasury

None

Atomic Energy Commission

" Maintain a capability to assess the effects of attack on the Commission's resources, both at national and field levels, and provide data to the Department of Defense."

Executive Order 11089, February 26, 1962
(Section 2 (h))

Civil Aeronautics Board

" Provide assistance, as appropriate, to FAA and to the Department of Defense in assessing the effects of attack on air carrier aircraft."

Executive Order 11090, February 26, 1963

Civil Service Commission

None

Federal Communications Commission

" Maintain a capability to assess the effects of attack on communication facilities and services subject to Commission regulation which are essential in a national emergency and to provide data to the Department of Defense."

Executive Order 11092, February 26, 1963
(Section 4 (b))

Administrator of General Services

" Maintain a capability to assess the effects of attack on Federal buildings, facilities, and resources, both at the national and field levels, and to provide data to the Department of Defense."

Executive Order 11093, February 26, 1963
(Section 3 (b))

Board of Governors of the Federal Reserve System
Federal Home Loan Bank Board
Farm Credit Administration
Export-Import Bank of Washington
Board of Directors of the Federal Deposit Insurance Corporation
Securities and Exchange Commission
Administrator of Small Business Administration
Administrator of Veterans Affairs

" Maintain a capability to assess the effects of attack on facilities under their jurisdiction and to provide data and assistance to the Department of Defense. "

Executive Order 11094, February 26, 1963
(Section 9 (b))

Board of Directors of the Tennessee Valley Authority
Railroad Retirement Board
Administrator of the National Aeronautics and Space Administration
Federal Power Commission
Director of the National Science Foundation

" Maintain a capability to assess the effects of an attack on facilities under their jurisdiction and to provide data and assistance to the Department of Defense and other agencies, as appropriate."

Executive Order 11095, February 26, 1963
(Section 7 (b))

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